AUTOMOTIVE · COMMUNICATIONS · TEST GEAR · COMPUTERS

No. 78

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ELECTRONICS

The Maplin Magazine

Britain's Best Selling Electronics Magazine

JUNE 1994 · £2.00

12V/230V INVERTER PROJECT...
Power *Where* You Need it...
Power *When* You Need it!

Communicate with a Packet Radio Modem

Charge/Discharge and Idle Monitor – Build it and Give Your Car's Electrics a Health Check!

Indispensable TTL Test Unit to Construct

Easy to Build and Fun to Play... Live Wire Game

Fascinating Features

Plus – Lots More Inside...

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JUNE 1994
VOL 13. No. 78

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Keep a weather-eye on your car's electrical system and avoid the need for a jump start! This indispensable project indicates whether the car's alternator is doing its job and whether the battery is being charged or discharged. An optional 'ammeter' can be also be added.

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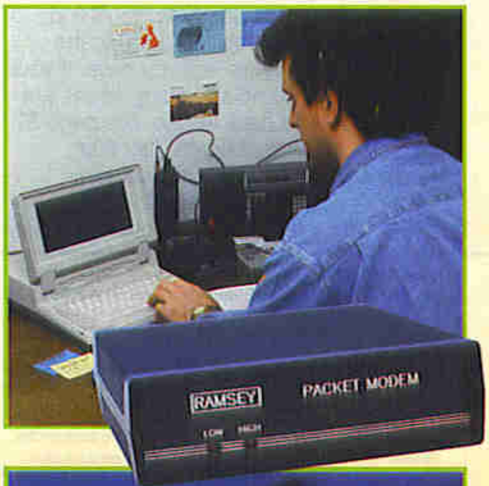

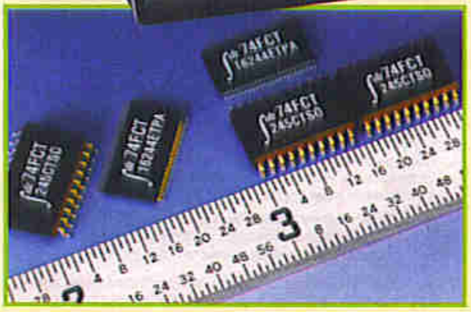

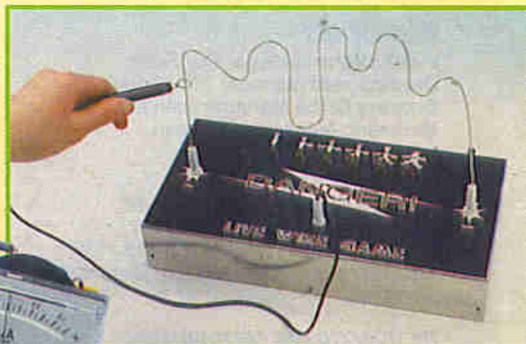

ABOUT THIS ISSUE . . .

Hello and welcome to this month's issue of *Electronics!*

This month's issue contains a fine collection of projects, some especially suitable for the summer season. The 12V DC/230V AC Inverter project is ideal for powering appliances of up to 250W from a 12V source – ideal for cars, camper-vans and caravans. For summer fund-raising events – such as school, church or charity fêtes – or simply for your own entertainment, the Live Wire Game is bound to be a hit. This modern version improves on the traditional steady hand game and is great fun to play.

The Car Charge/Discharge/Idle Monitor is designed to keep a check on your car's electrics. Whilst it is not strictly a 'summer' project, I'm sure you'll agree that fitting it in warm sunny weather is a sensible move. The chances are that it'll be in the winter months that it will prove most useful; a flat car battery or a faulty alternator discovered when it's cold and raining is inconvenient to say the least. . . .

For the digital experimenters amongst you the TTL Test Unit will prove to be indispensable; it's modular in design – you decide what sections, and how many of them, to build. If you're into computers and amateur radio you'll love the Packet Radio MODEM project – it combines the best of both hobbies. A great advantage is that you can stay connected as long as you like since there are no call-charges to incur!

Plus, there are some really super features to read, plus all of the usual regulars!

So from the rest of the team and me, until next month, have a 'jolly good read'!

Magazine Index

A comprehensive 14-page index to *Electronics – The Maplin Magazine* is now available from Maplin. The index covers every issue from December 1981 to December 1993. Included are details of every article, series and project published during that period. Conveniently arranged, sectionally and alphabetically, it'll take minutes instead of hours to find the exact issue number and page you need. You'll be able to rediscover a wealth of information you never knew you had! A list of all of the Corrigenda published is also included so you will be able to find details of changes or amendments. You'll find the index an invaluable addition to the issues of *Electronics* that you have. If your collection is incomplete, many issues are still available as back issues, see page 57 for details. The index costs just 80p*, Order As XU87U, you'll wonder how you ever managed without it!

* Note: normal mail order handling charges apply.

CORRIGENDA

April 1994, Issue No. 76, Semiconductor Processing – Part One Refining the Raw Materials

Page 20, Figure 1: Caption should read 'Typical Conductivity of Conductors, Semiconductors and Insulators'. Units throughout should be $(\Omega cm)^{-1}$. Resistivity is of course the inverse of conductivity.

The values quoted within the tables are extracted from the first chapter of *Semiconductors and Electronic Devices*, A. Barlev. Other texts may extend the limitations of the scale, quoting typical conductivity for conductors of $10^{5}(\Omega cm)^{-1}$ and 10 to $14(\Omega cm)^{-1}$ for insulators. All texts agree on the conductivity of semiconductors; for useful devices this lies in the region of 1 to $100(\Omega cm)^{-1}$.

A number of readers wrote questioning the authenticity of the semiconductor characteristics quoted in Table 2. We are happy to confirm that these have been cross-referenced to numerous sources and can thus be assumed correct.

ABC CONSUMER PRESS

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Published by Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Tel: (0702) 554155. Fax: (0702) 553935.
Lithographic Reproduction by Planagraphic Studios, 18 Sirdar Road, Brook Road Ind. Estate, Rayleigh, Essex SS6 7UY.
Printed in the United Kingdom by St Ives (Caerphilly) Ltd. Mid-Glamorgan, CF8 3SU.

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UK NEWSTRADE DISTRIBUTION

United Magazine Distribution Ltd., Castle House, 37-45 Paul Street, London EC2A 4PB. Tel: (071) 490 2020. Fax: (071) 490 1239.

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Project Ratings

Projects presented in this issue are rated on a 1 to 5 for ease or difficulty of construction to help you decide whether it is within your construction capabilities before you undertake the project. The ratings are as follows:

1 Simple to build and understand and suitable for absolute beginners. Basic of tools required (e.g., soldering iron, side cutters, pliers, wire strippers and screwdriver). Test gear not required and no setting-up needed.

2 Easy to build, but not suitable for absolute beginners. Some test gear (e.g. multimeter) may be required, and may also need setting-up or testing.

3 Average. Some skill in construction or more extensive setting-up required.

4 Advanced. Fairly high level of skill in construction, specialised test gear or setting-up may be required.

5 Complex. High level of skill in construction, specialised test gear may be required. Construction may involve complex wiring. Recommended for skilled constructors only.

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Kits, components and products stocked by Maplin can be easily obtained in a number of ways:

Visit your local Maplin store, where you will find a wide range of electronic products. If you do not know where your nearest store is, refer to the advert in this issue or Tel: (0702) 552911. To avoid disappointment when intending to purchase products from a Maplin store, customers are advised to check availability before travelling any distance.

Write your order on the form printed in this issue and send it to Maplin Electronics, P.O. Box 3, Rayleigh, Essex, SS6 8LR. Payment can be made using Cheque, Postal Order, or Credit Card.

Telephone your order, call the Maplin Electronics Credit Card Hotline on (0702) 554161.

If you have a personal computer equipped with a MODEM, dial up Maplin's 24-hour on-line database and ordering service, CashTel. CashTel supports 300-, 1200- and 2400-baud MODEMs using CCITT tones. The format is 8 data bits, 1 stop bit, no parity, full duplex with Xon/Xoff handshaking. All existing customers with a Maplin customer number can access the system by simply dialling (0702) 552941. If you do not have a customer number Tel: (0702) 552911 and we will happily issue you with one. Payment can be made by credit card.

If you have a tone dial (DTMF) telephone or a pocket tone dialler, you can access our computer system and place orders directly onto the Maplin computer 24 hours a day by simply dialling (0702) 556751. You will need a Maplin customer number and a personal identification number (PIN) to access the system. If you do not have a customer number or a PIN number Tel: (0702) 552911 and we will happily issue you with one.

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Prices

Prices of products and services available from Maplin, shown in this issue, include VAT at 17.5% (except items marked NV which are rated at 0%) and are valid between 6th May and 31st August 1994. Prices shown do not include mail order postage and handling charges, which are levied at the current rates indicated on the Order Coupon in this issue.

Technical Enquiries

If you have a technical enquiry relating to Maplin projects, components and products featured in *Electronics*, the Customer Technical Services Department may be able to help. You can obtain help in several ways: over the phone, Tel: (0702) 556001 between 2pm and 4pm Monday to Friday, except public holidays; by sending a facsimile, Fax: (0702) 553935; or by writing to: Customer Technical Services, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Don't forget to include a stamped self-addressed envelope if you want a written reply! Customer Technical Services are unable to answer enquiries relating to third-party products or components which are not stocked by Maplin.

'Get You Working' Service

If you get completely stuck with your project and you are unable to get it working, take advantage of the Maplin 'Get You Working' Service. This service is available for all Maplin kits and projects with the exception of: 'Data Files'; projects not built on Maplin ready etched PCBs; projects built with the majority of components not supplied by Maplin; Circuit Maker ideas; Mini Circuits or other similar 'building block' and 'application' circuits. To take advantage of the service, return the complete kit to: Returns Department, Maplin Electronics plc., P.O. Box 3, Rayleigh, Essex, SS6 8LR. Enclose a cheque or Postal Order based on the price of the kit as shown in the table below (minimum £17). If the fault is due to any error on our part, the project will be repaired free of charge. If the fault is due any error on your part, you will be charged the standard servicing cost plus parts.

Kit Retail Price	Standard Servicing Cost
up to £24.99	£17
£25 to £39.99	£24
£40 to £59.99	£30
£60 to £79.99	£40
£80 to £99.99	£50
£100 to £149.99	£60
Over £150	£60 minimum

Readers Letters

We very much regret that the editorial team are unable to answer technical queries of any kind, however, we are very pleased to receive your comments about *Electronics* and suggestions for projects, features, series, etc. Due to the sheer volume of letters received, we are unfortunately unable to reply to every letter, however, every letter is read — your time and opinion is greatly appreciated. Letters of particular interest and significance may be published at the Editors discretion. Any correspondence not intended for publication must be clearly marked as such.

Write to: The Editor, Electronics – The Maplin Magazine, P.O. Box 3, Rayleigh, Essex, SS6 8LR.

TECHNOLOGY WATCH!

with Keith Brindley

There's no doubt about it, *personal* communications are set to become the *thing* of the nineties. We entered the decade with a few mobile communications systems which, yes, do work to an extent but are, after all, hardly useful for anything except phoning home to tell your partner that the train has been delayed, and you won't be back till 8pm.

On the other hand, it looks like we'll leave the decade – and enter the next century – with miniature systems which will allow us to phone, fax, receive and send data, watch TV or even video on demand, listen to radio or your favourite music, and who knows what else. This will all be available from a hand-held communicator, most commonly having the title *Personal Digital Assistant* (PDA).

Forerunning devices have been introduced already, of course, and one or two of them have been considered in this very column (Apple's Newton, and Amstrad's PenPad), but these are simply nothing compared with what's to come.

Motorola has recently been showing a version of a PDA called Envoy, which is pricey at the moment at £1,200 or so, but which points the way forward. It uses a new type of operating system which is an extension of the icon-metaphor method, in which icons are used to represent real-life objects and tasks. As such, the telephone looks like a telephone, and so on.

The designers of the system, called Magic Cap (the *Cap* standing for *Communications Application Program*), include some originally involved in the Apple Macintosh operating system back in 1984, so they have more than just a little experience in producing an easy-to-use and, what's more, easy-to-get-to-grips-with operating system. But Magic Cap takes the symbolic metaphor one stage further than the Mac. Where the Mac is primarily a computer, doing computing tasks just like any other computer (only more easily for the user), Magic Cap endeavours to be a complete simulation of a human environment. Magic Cap's opening view, for example, is of the interior of an office, with 3D icons for standard office bits and bobs – telephone, fax, in and out trays, diary, and so on. You can move out to a hallway, where doors lead to other rooms; from there you can move out to a street, complete with post office, travel agent, and so on. The designers' single aim was to create a system which looks just like the real world, and which anyone can use, and that they have done. You don't have to know a single thing about computers or data communications to be able to use Envoy.

Whether Magic Cap becomes the world's standard for PDAs is debatable. Apple is a long way down the road (the *real* road, not the iconic one) with its handwriting-recognising (and, soon to be introduced, voice-recognising) Newton. Microsoft has PenWindows, and there are others too. Maybe there'll never be a single standard – there doesn't need to be with careful planning. As long as all these different systems can communicate properly between themselves, there's no need for a standard at all. Users will just buy a PDA because they want to communicate and they like the particular human interface: Magic Cap, Newton, or Windows, that's all. Whether the PDA you want to communicate with is the same type as yours is, after all, irrelevant. This simply mirrors the way computing itself is heading.

Magic Cap works in combination with a hardware controlling system called Telescript. In effect, Telescript is a complete mechanism to control hardware, incorporating a language, a controlling engine, and the necessary protocols involved. Magic Cap merely sits atop Telescript for products like Envoy. In the future, Telescript will probably start to crop up in other products such as telephones, televisions, video recorders, and so on. It's only Magic Cap which defines the device as a PDA. Put another interface onto Telescript, and it could be another product.

Weighing Up

I have to say that I have mixed feelings about all this attention to *personal* aspects – *personal* stereos, *personal* phones, *personal* communications. Things like virtual reality don't help either. I get a little worried that people will lose the ability to relate in a human sense if we don't actually communicate in the *non*-personal way, that is, by talking to each other. Don't get me wrong, I'm as guilty as the next. I have a personal stereo which I use to prevent people from talking to me when I don't want to be interrupted, I love gadgets and widgets and (maybe) will get a PDA just as soon as they become cheap enough, and as a freelance there can be times when I don't speak to an outside person for literally weeks.

But here I'm not actually talking about the *personal* level. Instead I refer to our whole culture, and I wonder whether it will survive as these personal things become more common and begin to take over our human communication tasks.

This is a Recorded Announcement

It will surprise many readers (probably around 80% if the results of a recent survey by NOP last year are anything to go by) that all is not quite what it seems when you dial a mobile user with a cellular telephone number.

If that user's cellular phone is turned off, or if it's simply out of reach to the network, you'll get a recorded announcement telling you as such. However, unlike recorded messages generated from cabled telephone systems, you're actually being charged for the time you listen to the cellular message! Couple this with the higher charges incurred anyway when you do actually connect with your chosen recipient, and it makes you wonder whether you should call a cellular user in the first place, doesn't it?

The opinions expressed by the author are not necessarily those of the publisher or the editor.

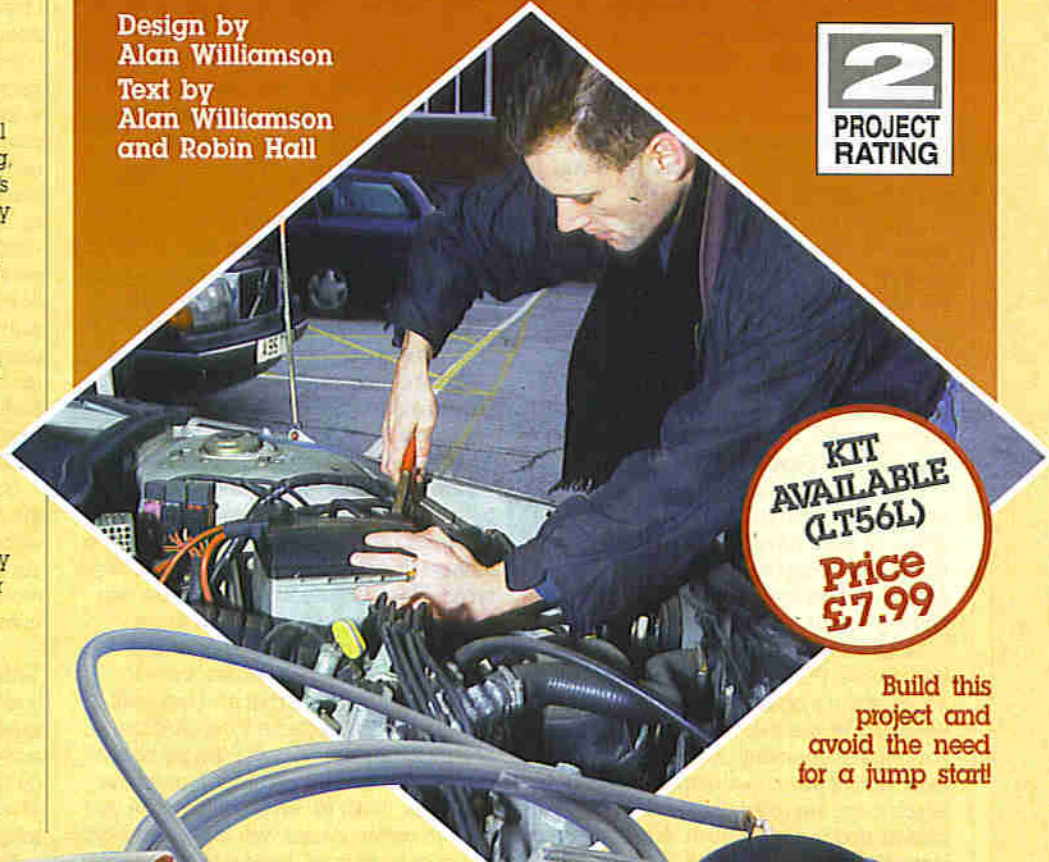
CAR BATTERY CHARGE/DISCHARGE IDLE MONITOR

Design by
Alan Williamson
Text by
Alan Williamson
and Robin Hall

2
PROJECT RATING

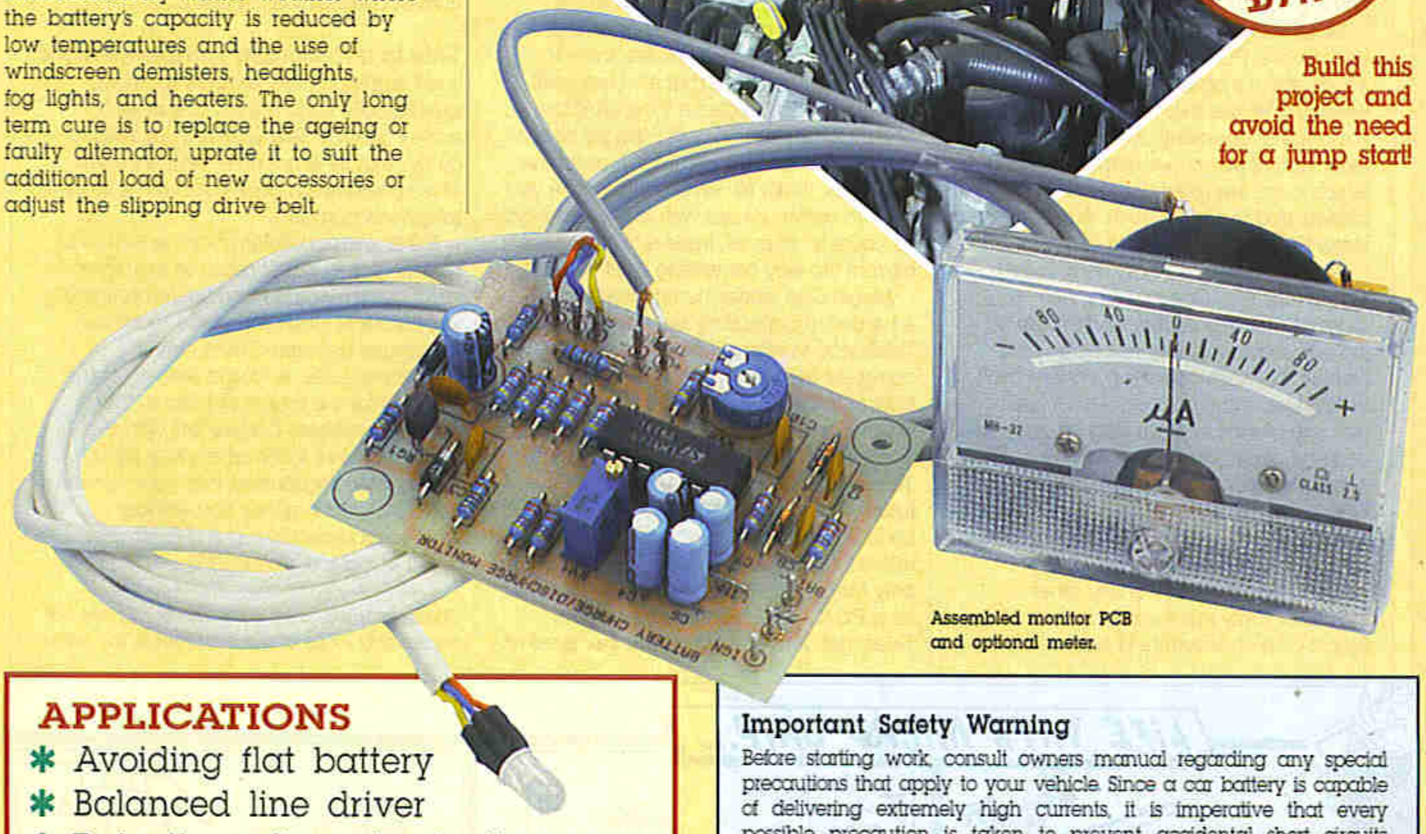
The dashboard of the modern family car has an ignition warning light, which is normally in the form of a battery symbol that illuminates red when the car's alternator is not producing sufficient output to supply the electrical needs of the car. The alternator serves two purposes: to replace the energy lost from the battery during starting; and to supply the electrical requirements of the car whilst the engine is running, i.e. ignition, lights, car radio, etc. The output current rating of the alternator is chosen by the car manufacturer to be generally sufficient for the car's needs.

If a fault develops with the alternator, its drive belt snaps or is slipping, the ignition warning light will illuminate. However, generally speaking, no indication is given if the alternator's output is not sufficiently high to supply the electrical requirements completely. This may be the case with an ageing alternator or where new accessories have been added – such as high power driving lights, a powerful car stereo, a radio transceiver, etc. In such instances the alternator cannot supply sufficient current and the battery supplies the difference. Clearly the battery is being discharged instead of being charged, and over a period of time it is likely that there will be insufficient energy stored in the battery to start the car. This situation is further exacerbated by winter weather where the battery's capacity is reduced by low temperatures and the use of windscreen demisters, headlights, fog lights, and heaters. The only long term cure is to replace the ageing or faulty alternator, uprate it to suit the additional load of new accessories or adjust the slipping drive belt.



KIT AVAILABLE (LT56L)
Price £7.99

Build this project and avoid the need for a jump start!



Assembled monitor PCB and optional meter.

APPLICATIONS

* Avoiding flat battery
* Balanced line driver
* Detecting alternator faults

FEATURES

* Simple to build * Easy to install
* Tri-colour visual indication
* Optional centre zero meter

Important Safety Warning

Before starting work, consult owners manual regarding any special precautions that apply to your vehicle. Since a car battery is capable of delivering extremely high currents, it is imperative that every possible precaution is taken to prevent accidental short circuits occurring. Remove all items of metal jewellery, watches, etc. Before connecting the module to the car electrics, the battery should be disconnected. Helpful hint – Remove ground connection first, to prevent accidental shorting of the (+) terminal to the bodywork or engine, assuming negative earth vehicle. It is essential to use a suitably rated fuse in the supply to module. The wire used for the connections should also be rated to safely pass the required current. If in any doubt as to the correct way to proceed, consult a qualified automotive electrician.

So what is the answer? Simple, some form of current monitor. Traditionally this task was performed by an ammeter, but the modern family car, generally, is not fitted with an ammeter, as often found on a 'sports' model or an older car. The modern family car dashboard is generally crammed with other 'essential' features (i.e. 'sales gimmicks') leaving no room for an ammeter. But there is usually enough room to fit a 5mm diameter LED somewhere....

This is where this project is very useful, as it gives a visual indication of whether current is being drained from the battery, whether charge is given back to the battery or the battery is neither being charged nor discharged. The project can even be fitted with an optional 'ammeter' (if you have enough room on the dashboard!).

Connecting the module is very simple, since it only has three wires, and should take considerably less time to fit than trying to persuade a passing motorist to stop to give you a jump start on a dark night in the pouring rain!

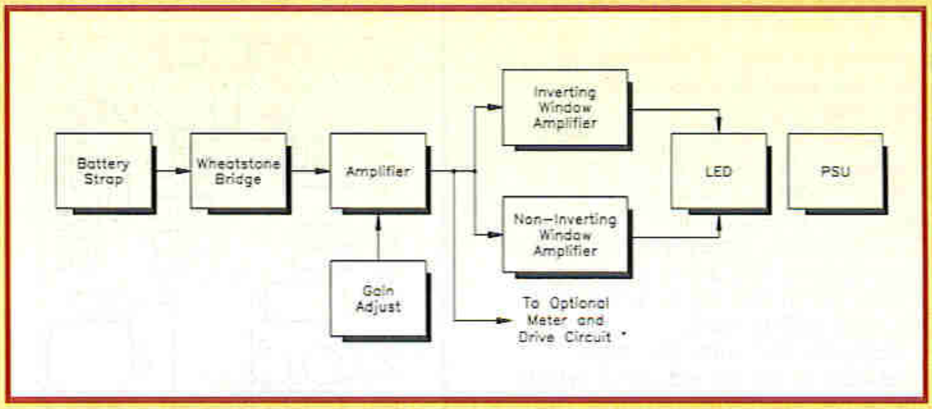


Figure 1. Block diagram of Car Battery Charge/Discharge/Idle Monitor.

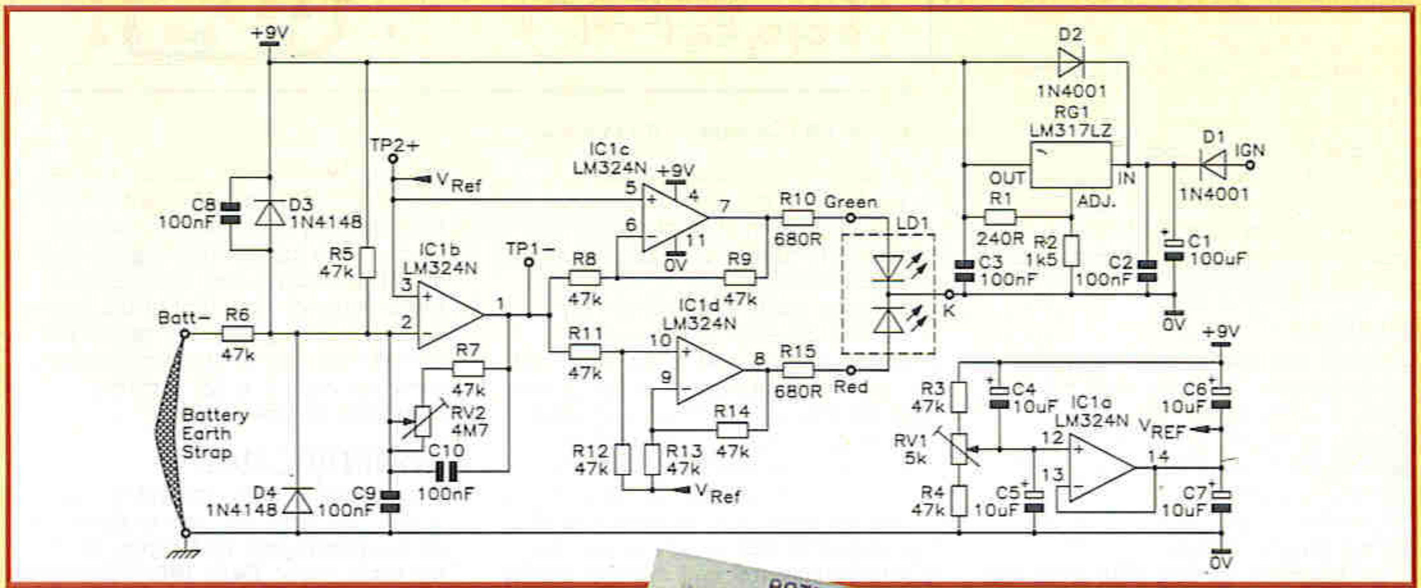


Figure 2. Circuit diagram of Car Battery C/D/I Monitor.

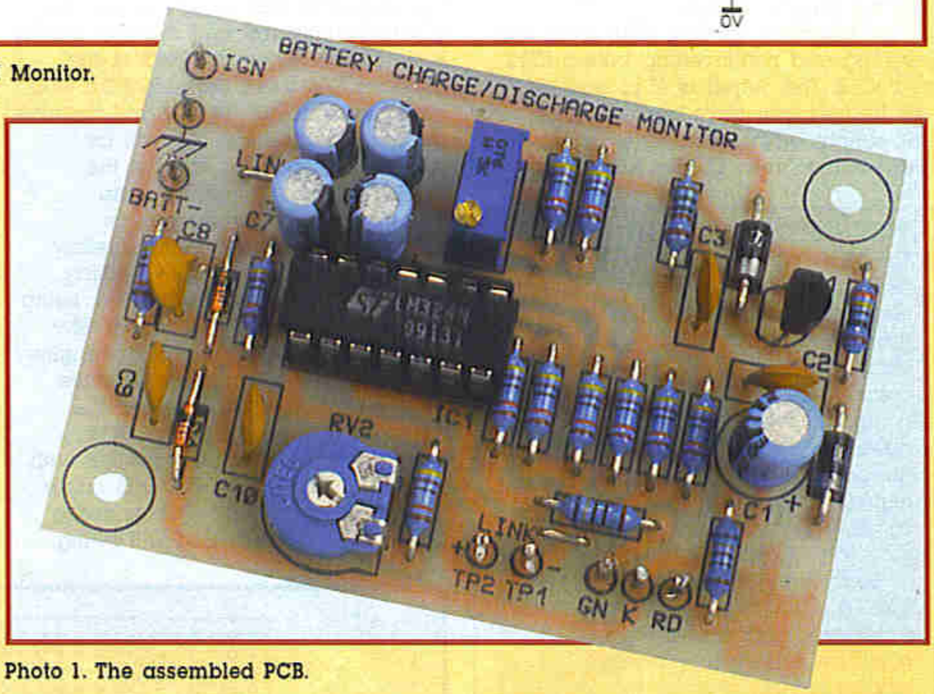


Photo 1. The assembled PCB.

CIRCUIT DESCRIPTION

The block diagram of the Battery Charge/Discharge/Idle Monitor is given in Figure 1, this, as well as the circuit diagram in Figure 2, will help illustrate how the circuit operates. Let's begin with the power supply (it seems a fair place to start as any!).

Diode D1 prevents any possible damage from reverse polarity connections. Capacitors C1 and C2 provide low and high frequency decoupling for the regulator RG1; which is needed to prevent supply variations affecting operation of the unit. The resistors R1 and R2 set the output voltage of the regulator to approximately +9V DC. Capacitor C3 provides high frequency output decoupling of the regulator, as well as aiding stability. Diode D2 affords additional protection to the regulator in the hostile environment of the car.

Resistors R3, R4 and preset RV1 have dual functions, apart from being the half supply voltage reference for the half supply generator IC1a; they also form part of the 'Wheatstone bridge', more on this later . . . The preset RV1 is required because the quad op amp is not of instrumentation grade (to keep the cost down) and therefore, inherent output offset voltages will occur, which require nulling out.

Capacitor C4 and C5 decouple the reference voltage to the supply rails. If noise was injected into the circuit, the reference voltage would remain unaffected because of the symmetry of the circuit. Capacitors C6 and C7 have the same function at the output of IC1a.

Diodes D3 and D4 serve to protect the input of the op amp IC1b; while

Specification

Operating voltage:	+12 to +25V DC
Current consumption:	15mA (max)
Visual indicators:	Tri-colour LED Optional centre zero meter

capacitors C8 and C9 decouple the input and reject any high frequency noise picked up.

Resistors R5 and R6 again serve dual functions as they form the second half of the 'Wheatstone bridge' as well as biasing the inverting input of op amp IC1b to half the supply voltage. Resistor R7 and preset RV2 determine the gain of IC1b, which can be set between x2 and x200 (6dB to 46dB).

Capacitor C10 limits the upper bandwidth of the op amp IC1b which will be between 0·7Hz and 34Hz. The actual cut-off frequency is determined by the wiper position of the preset RV2. The capacitor C10 also provides damping of the optional meter by reducing the slew rate of the op amp IC1b.

Op amps IC1c and IC1d form an analogue window comparator, where R8, R9 and op amp IC1c form a unity gain *inverting* buffer, whilst R11, R12, R13, R14 and op amp IC1d form a similar, but complementary, unity gain *non-inverting* buffer.

OVERVIEW

Assuming that the module is installed and the ignition is turned on but the engine is not running, the inverting input of op amp IC1b will be approximately at half the supply, this can be finely adjusted by RV1. Therefore the output will also be at half the supply voltage.

The output of op amp IC1b feeds the inverting and non-inverting buffers IC1c and IC1d. The output of IC1c and IC1d will be (yes, you have guessed it!) at half supply, which illuminates both the red and green LEDs at similar brightness levels, which combine to produce an orange/yellow light.

Starting the engine will draw (significant) current from the battery; a potential difference will appear across the battery earth strap, albeit very small. The potential at the battery negative terminal end of the strap will be negative with respect to the chassis. This will cause the output of op amp IC1b to swing towards the positive supply rail (because it is inverting); by how much will depend on the potential across the strap and the setting of RV2. Op amp IC1d will swing towards the positive supply rail and therefore supply more current to the red half of the tri-colour LED (LD1). Op amp IC1c will swing towards the 0V rail and therefore the green half of the LD1 will be extinguished; the net result is the red LED indicating battery drain.

After starting the engine, the LED will return to the orange/yellow condition while the engine is idling, indicating that the battery is not being drained or charged. With a partially discharged battery, revving the engine will cause the alternator to produce more power which will charge the battery. The potential at the battery negative terminal will be positive with respect to the chassis. This will cause the output of op amp IC1b to swing towards the 0V rail. IC1d will swing towards 0V rail extinguishing the red half of LD1. Op amp IC1c will swing towards the positive supply rail and supply more current to the green half of LD1, indicating that the battery is being charged. Note that, if the battery has not been significantly discharged, the LED will stay in the orange/yellow condition since it is not drawing significant charge current.

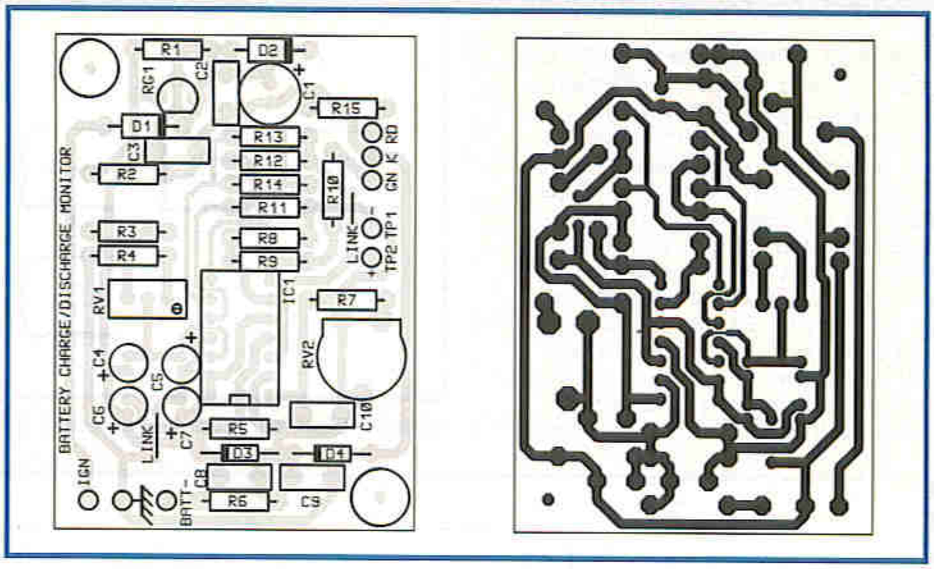


Figure 3: (a) PCB legend; (b) PCB track.

CONSTRUCTION

Construction is fairly straight forward, refer to the Parts List and to Figure 3a for the PCB legend and Figure 3b for the track layout. Begin with the smallest components first; working up in size to the largest; be careful to orientate correctly the polarized devices, i.e. electrolytic capacitors, diodes, regulator and IC. The IC should be inserted into the socket last of all. Thoroughly check your work for misplaced components, solder whiskers, bridges, and dry joints. Finally, clean all the flux off the PCB using a suitable solvent. Photo 1 shows the assembled PCB.

Refer to Figure 3c for the stripboard layout for building the meter calibration circuit to be used in conjunction with the optional meter.

Figure 4 shows the drilling details for the optional plastic box with base (YN36P). Do not fit the Monitor PCB into the box at this stage.

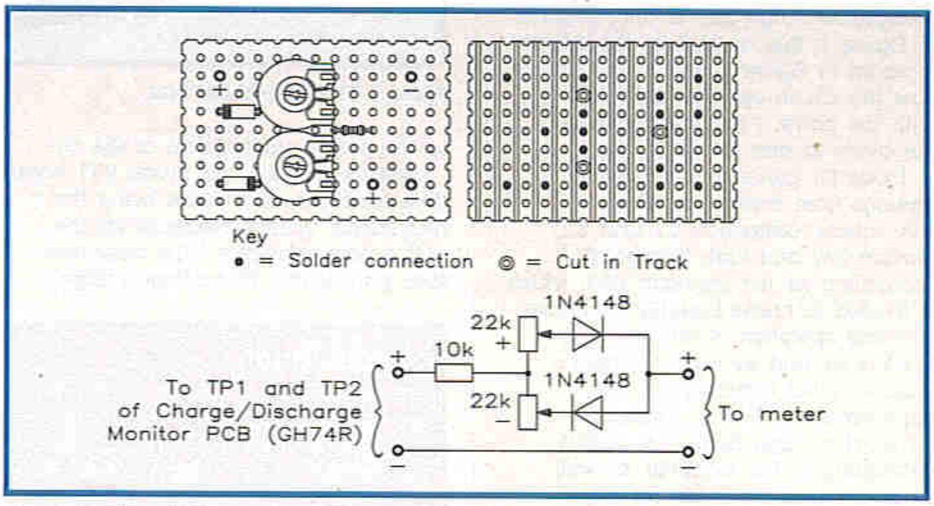


Figure 3c. Circuit diagram and stripboard layout of optional meter circuit.

WHEATSTONE BRIDGE

The Wheatstone bridge was originally developed in the early days of electronics (when valves and transistors were yet to be invented) to obtain an accurate reading of an unknown resistance. The problem with *non-bridge* techniques was that if an ammeter was inserted in series with the unknown resistance and a poorly regulated supply applied across the circuit, the ammeter readings would vary with supply voltage variations.

Because the meter in bridge circuit takes a differential measurement, the supply variations are effectively cancelled out, and an accurate reading is then obtained.

The bridge measurement technique, in a modified form, is also used to find unknown inductance and capacitance. However, today's technology (the pocket digital multimeter) has replaced the bridge circuit in all but the most demanding of applications. A modern application of the bridge circuit is measuring stress and strain, where one arm of the bridge is formed by a resistive strain gauge. However, it is more usual to find all four resistor arms mounted on a membrane, which is called a strain gauge rose.

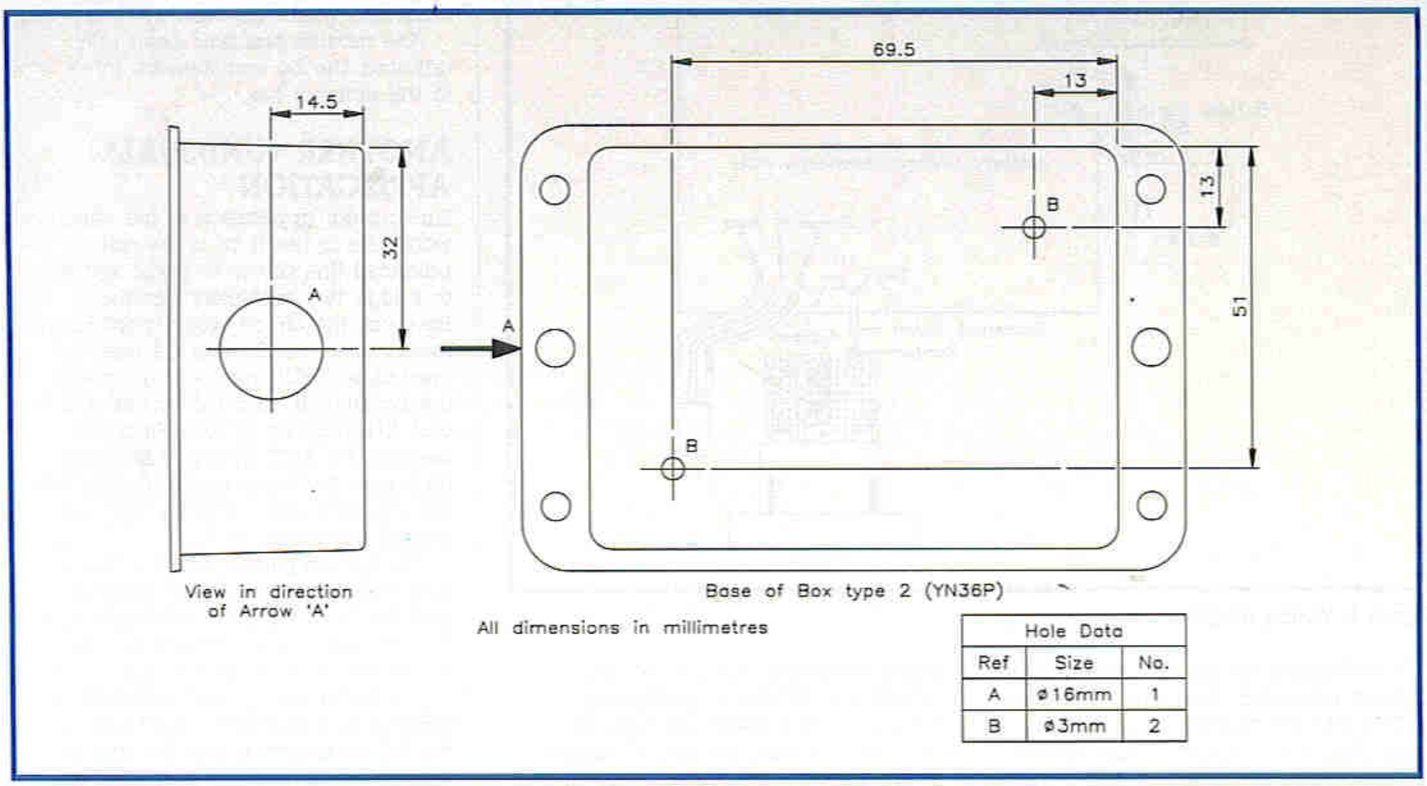


Figure 4. Box drilling details.

TESTING AND SET UP

The optional meter adjustments and testing can be made on the bench. The tools required are multimeter, preferably digital for accuracy (but not required if the optional meter used). A preset adjuster tool or a small flat blade screwdriver, a +12 to +25V DC power supply and a new 1·5V cell.

If the optional meter is employed, the meter should be set to zero via its inbuilt adjustment mechanism. Connect the meter to the (+) and (-) points on the stripboard, and the stripboard to TP1(-) and TP2(+) pins of the Battery Charge/Discharge Monitor using screened cable. Set the meter calibration presets to centre travel.

Connect a shorting link between the BATT (-) terminal and CHASSIS on the PCB; adjust RV2 fully clockwise; apply power and wait a few seconds for the circuit to stabilise.

Connect a meter (which has been previously set to a 10V or higher range) between TP1 and TP2; adjust RV1 until the meter reads 0V, or the optional meter reads 0. See Table 1 for readings. Remove the shorting link; the LED will turn green and the meter will deflect to the right. Adjust the (+) preset until the meter reads +100. Connect the test battery plus (+) terminal to the CHASSIS connection and the battery minus (-) terminal to the BATT (-) connection. The LED will turn red; adjust the (-) preset until the meter reads -100.

The module is now fully tested and can now be installed into the optional box; refer to Figure 5 which shows the exploded assembly. Do not fit the lid as RV1 and RV2 will require readjustment once installed into the car.

OPTIONAL METER 100% fsd	RV1 MIN	RV1 MAX
INPUT VOLTAGE	+3·45V, -2·75V	+45mV, -45mV
CURRENT DETECTION (0·1Ω)	+34·5A, -27·5A	+450mA, -450mA

Table 1. RV1 settings and corresponding minimum and maximum readings.

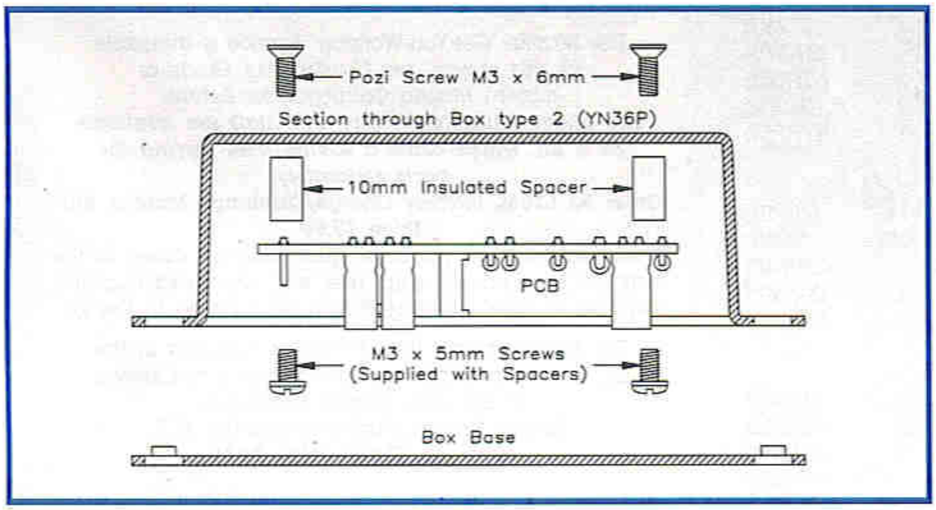


Figure 5. Assembly diagram.

INSTALLATION

Referring to the full wiring diagram as shown in Figure 6, decide whether you wish the module to monitor the starter-motor drain current and the battery charge/discharge/idle condition or just the battery charge/discharge/idle condition. If the former, connect the module's supply to the ignition line; if the latter, connect the supply to the accessory line. In both cases a 100mA quick blow fuse must be wired in the positive supply wire.

To readjust RV1, turn the ignition on, but do not start the engine. If you have an engine management system, wait a minute or so for it to time out and shut down). Ensure that all the lights/radio, etc. are off, and adjust RV1 for a 0V multimeter reading, or 0 for the optional meter.

The adjustment of RV2 will depend upon whether the LED is to be used on its own or with the optional meter.

The adjustment of RV2 with the LED only, is entirely user determined; adjusting RV2 fully clockwise for maximum sensitivity would be the most popular setting, as it would give a definite charge/discharge indication.

If the starter-motor drain current is to be monitored the engine must be turned over, as this is when most power is drawn from the battery. Adjust RV2 fully anticlockwise; then turn over the engine and adjust RV2 clockwise until the optional meter reads -100.

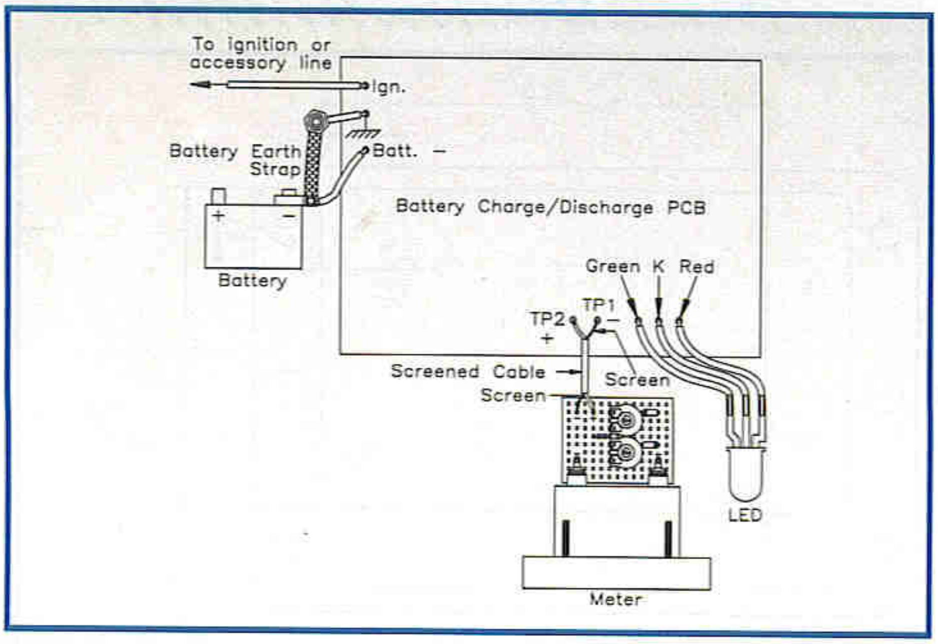


Figure 6. Wiring diagram.

If everything except the starter-motor is to be monitored, then the calibration of RV2 can be adjusted in two other ways. First is to connect a high current ammeter (20A minimum) in series with the positive battery lead and turn on the headlights *without* the engine running. Note the reading on the ammeter and adjust RV2 until the optional meter reads the same. Reverse the Batt (-) and chassis connections, the optional meter will now deflect in the other direction, readjust the meter calibration preset until the optional meter reads the same as the current meter. Reconnect the Batt (-) and chassis connections for permanent installation. The meter will then be calibrated to read the actual current drawn through the battery strap in both directions.

The second method is definitely *not* neighbourhood friendly, which is to turn on all the accessories *without* the engine running. This means all the lights, including the interior, brake and hazard lights, stereo at full volume, horn, etc., (*don't* do it at times or in a location when it will cause a nuisance) and then adjust RV2 for the meter to read somewhere between -80 and -100.

The module has now been fully adjusted; the lid can then be fitted to the optional box.

ANOTHER (UNUSUAL) APPLICATION

An unusual application of the circuit would be to use it as a low-cost balanced line driver or phase splitter to bridge two amplifiers together. However, the circuit would need slight modification, i.e. C8 and C9 removed, the value of C10 reduced to increase the bandwidth, and the values of R10 and R15 reduced to 22Ω. Fit a link between (-) BATT and CHASSIS, and then feed the input signal directly into the inverting input of IC1b with the ground connected to V_{REF}.

The hot (in-phase) signal is taken from the LED green anode connection, and the cold (out-of-phase) signal from the LED red anode connection, when the screen is connected to V_{REF}.

Changing the op amp package to a LM837N or a TL074CN would improve the AC performance, but the supply voltage would need to be increased. Changing the value of R2 to 2k2 would suffice for small signals (maximum value 6k8 for LM837N and TL074CN, and 5k6 for the supplied LM324N); input and output coupling capacitors are recommended.

Note that the supply voltage 0V and the audio input and output screens must not share a common return path, otherwise V_{REF} will be shorted out to 0V.

BATTERY CHARGE/DISCHARGE/IDLE MONITOR PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1	240Ω	1	(M240R)
R2	1k5	1	(M1K5)
R3-9, 11-14	47k	11	(M47K)
R10,15	680Ω	2	(M680R)
RV1	5k 22-turn Cermet Preset	1	(UH24B)
RV2	4M7 Horizontal Enclosed Preset	1	(UH11M)
CAPACITORS			
C1	100µF 25V Radial Electrolytic	1	(FF11M)
C2,3, 8-10	100nF 50V Mini Disc Ceramic	5	(BX03D)
C4-7	10µF 50V Radial Electrolytic	4	(FF04E)
SEMICONDUCTORS			
IC1	LM324N	1	(UF26D)
RG1	LM317LZ	1	(RA87U)
D1,2	1N4001	2	(QL73Q)
D3,4	1N4148	2	(QL80B)
LD1	Multicolour LED 5mm	1	(YH75S)
MISCELLANEOUS			
	14-pin DIL IC Socket	1	(BL18U)
	Single-ended PCB Pins 1mm (0·4in.)	1Pkt	(FL24B)
	PCB	1	(GH74R)
	Instruction Leaflet	1	(XU68Y)
	Constructors' Guide	1	(XH79L)
OPTIONAL (Not in Kit)			
	15k Min Res	1	(M15K)
	22k Horizontal Enclosed Preset	2	(UH04E)
	1N4148	2	(QL80B)
	Strip Board Type 1039	1	(JP46A)
	M3 x 10mm Insulated Spacer	1Pkt	(FS36P)
	M3 x 6mm Pozi Screw	1Pkt	(BF36P)
	No. 6 x ⅜in. Self-tapping Screw	1Pkt	(LR67X)
	Single-ended PCB Pin 1mm (0·4in.)	1Pkt	(FL24B)
	2in. Panel Meter 100-0-100µA	1	(RW98G)
	Box with Base Type 2	1	(YN36P)
	Min Single Core Lapped Screen	AsReq.	(XR15R)
	4-Wire Cable	AsReq.	(XR89W)
	In-line Car Type Fuseholder	1	(RX51F)
	100mA Fuse 1¼in.	1	(WR08J)
	LED Clip Convex 5mm	1	(UK14Q)
	16mm PVC Sealing Grommet	1	(JX77J)
	1·6mm Heat Shrink Sleeving	1	(BF86T)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT56L (Battery Charge/Discharge Monitor Kit) Price £7.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new item (which is included in the kit) is also available separately, but is not shown in the 1994 Maplin Catalogue.

Battery Charge/Discharge Monitor PCB

Order As GH74R Price £2.49

In many situations, the use of existing PSTN (Public Switched Telephone Network) lines for conveying computer data is a compromise, and in some cases downright unsuited. Corruption of data and security can be a problem, and its use during peak business hours can be unreliable and expensive.

The data rates that can be stuffed down a phone line are quite low (2,400-bit/s is the current most common standard), and if the line is bad, modems may switch over to even slower rates (as low as 300-bit/s), causing huge delays and expensive calls. Of course, for portable operation one of the cellular telephone networks have to be used, which are incredibly expensive, and calls are often subject to severe signal degradation, causing data errors.

What is PAKNET?

by Martin Pipe

Top: Paknet in a retail application.
Top Left: A Paknet Radio Pad. Note the compact size.
Left: The Paknet Base Station, normally located at a cellular repeater site.
Above: the Radio-Pad has two user ports, allowing for two completely independent applications. For example, one port may be connected to an EFTPoS terminal, the other possibly to a security system or computer.

Purpose-designed data transmission lines – such as those conforming to the CCITT X.25 packet standard – overcome the latter problem, but tend to be expensive, and hence not economically viable if only fairly small amounts of data (for example, lumps as small as 1,000 bits) need to be sent infrequently. Everyday examples of such unpredictable low-volume traffic are EFTPoS (Electronic Fund Transfer Point of Sale) and credit card authorisation, which are encountered in retailing.

Of course, the use of wire as the transmission medium is potentially hazardous – after all, wires are subject to the forces of nature, as those living or working in outlying regions will testify. Wires are also vulnerable to deliberate tampering – particularly worrying for alarm system operators, and other providers of sensitive services or information. The cost of setting a line up in the first place may also be prohibitive, particularly to remote areas where such lines are not already in existence.

With these problems in mind, the Paknet system was introduced in February 1990. Originally developed by Racal Research, the service is run by Paknet Ltd., a joint venture between the Vodafone Group plc (another Racal subsidiary) and Mercury Telecommunications Ltd. A public packet-switched data network (using the X.25 protocol), Paknet uses radio as its transmission medium. This provides considerable advantages for many applications, as well as creating new possibilities, unimaginable before the introduction of such a system – remote monitoring and interactive information services will be discussed later. Since X.25 is used, Paknet can be connected to existing networks – in many cases allowing private network operators to make additional revenue from spare capacity. The X.25 system, as implemented on Paknet, allows data transmission rates of 9,600-bit/s. to be attained as standard – file compression could increase this still further, if required.

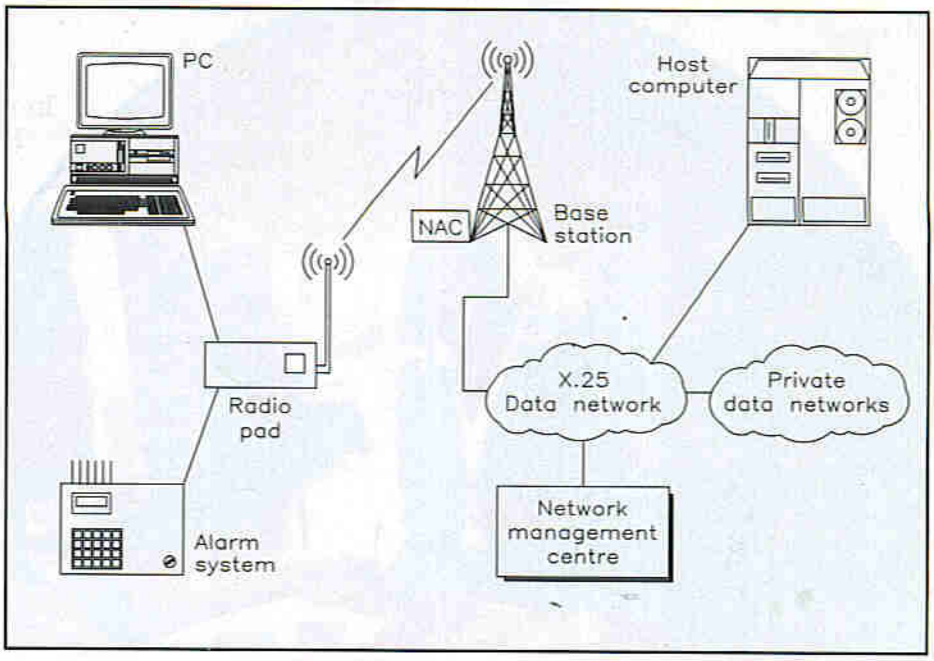


Figure 2. The same system, based around Paknet.

A conventional data transmission system using a PSTN line is shown in Figure 1. Users are connected to other users or a private data network via modems. Between the modems of the host and user, much happens. Signal conditioning, telephone exchanges, multiplexing/demultiplexing equipment, and not least the line itself, collectively degrade the signals and limit data transmission speeds. Even over physically short hops (theoretically, two adjacent offices on different lines) the nearest available exchange could still be several miles away, and during peak periods could be further away still, bringing ever-increasing amounts of PSTN hardware into play.

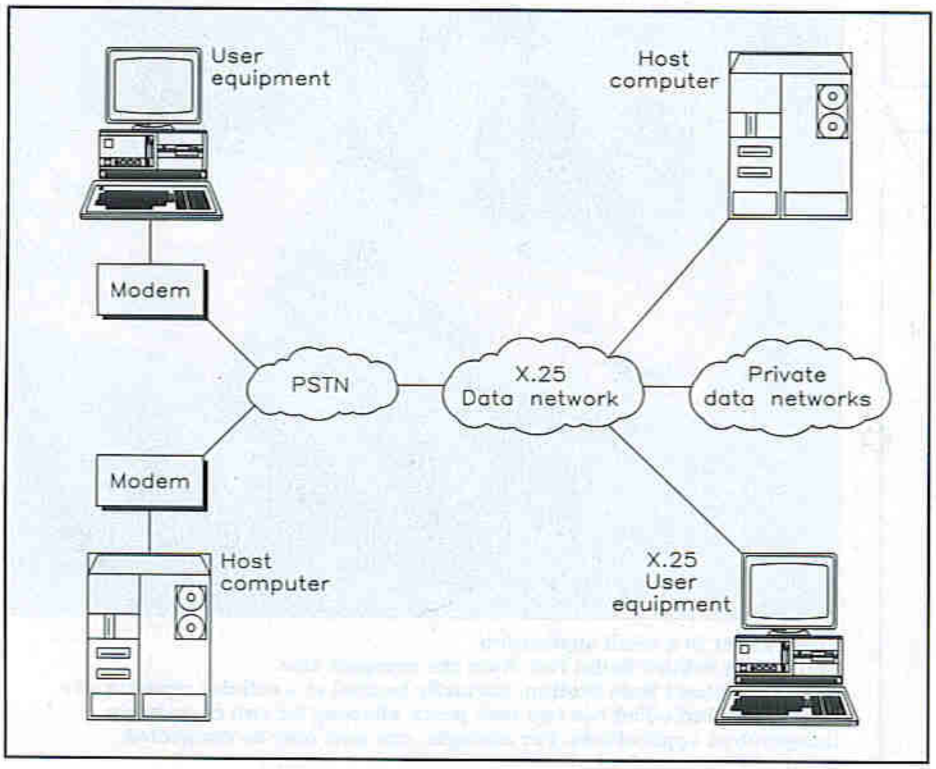


Figure 1. Data communications system based around a PSTN line.

Enter the Radio Pad

The Paknet alternative is shown in Figure 2. Instead of a PSTN modem, a small black box, known as a 'radio pad', is used. The device *does not* look like a reporter's notebook, the word 'pad' actually being an acronym for Packet Assember/Disassembler. Regardless of its name or shape, the unit does exactly the same job as a modem, but contains a VHF radio transceiver instead of a phone jack. The device, which weighs less than 1kg, is powered by a 12V DC supply – it has been designed to be portable, and thus make the most of the flexibility that independence of a comms line provides. Even when the on-board 4W transmitter is working, the radio pad only consumes 500mA, and so could be powered from a car's battery for mobile operation, or by a Ni-Cd battery pack. In receive mode, the current consumption is even less at 150mA.

The range of the radio pad is typically 10 miles with its internal aerial, although this will decrease in urban areas. In such instances, the use of a roof or pole-mounted aerial is recommended. Outside the full coverage area, an external aerial will be required anyway; under ideal conditions, ranges as much as 50km can be attained.

Connection to the computer equipment is via two RS232 ports, which are available on two 25-way 'D' connectors. The use of two serial ports means that two completely independent applications can be catered for separately. For example, an EFTPoS terminal can be hooked up to one port, and a PC to the other. This saves 'fiddling around the back' a nightmare for non-technical personnel, or the use of switch boxes.

Apart from power and aerial connectors, there's not really much else to the Radio Pad, apart from power and 'in use' LEDs. As far as the user is concerned, it truly is a 'black box' in the literal sense – just like the PSTN modem that it replaces.

Base Station

At the other end of the radio link is the base station, which links up to any available X.25 node. With its data capacity of 64K-bit/s, each base station can handle a considerable number of independent Paknet applications at any instant, and can cope with many hundreds within its vicinity. Hardly surprisingly, base stations are located at Vodafone sites, but could be installed practically anywhere provided the required external lines are present. At the heart of the base station is the Network Access Controller (NAC), which consists of a radio transceiver and X.25 interface circuitry. In fact, each base station has two NACs, one of which is always available, should the other fail. This helps to provide continuity of services, although there is always the possibility of power supply, aerial or line failure. The first problem can be overcome by the use of an uninterruptible power supply (UPS), although each NAC does consume around 305W of power (DC and AC supply options are available). For ease of installation, the aerial is a simple omnidirectional whip.

Installation of base stations is progressing at a rapid pace, with around 75% of Britain covered by Spring 1994. The stations (numbered at 136, at the time of writing) are arranged in a cellular '7 zone repeat pattern', as shown in Figure 3, to achieve efficient coverage. As has been proven for nearly ten years with mobile phone systems, this system is spectrum efficient, reduces co-channel interference and is flexible in its implementation. In addition, it makes for easier network planning and installation, since suitable sites will already have mobile telephone repeaters and the required infrastructure. Normally, all that is required is the X.25 link.

In February 1990, Paknet started in the Greater London area with some ten base stations connected to two X.25 exchanges. Bearing in mind that most of the country can now make use of the service, a mere three years later (refer to the coverage map of Figure 4), the level of progress has been astounding.

Network Management Centre

The Network Management Centre (NMC) augments the activities of each existing X.25 network management centre, which is responsible for the routing of users in each node, subscriber billing and maintenance. Among its tasks are the control of each NAC connected to that particular X.25 network, the downloading of NAC software updates, fault location, radio pad test

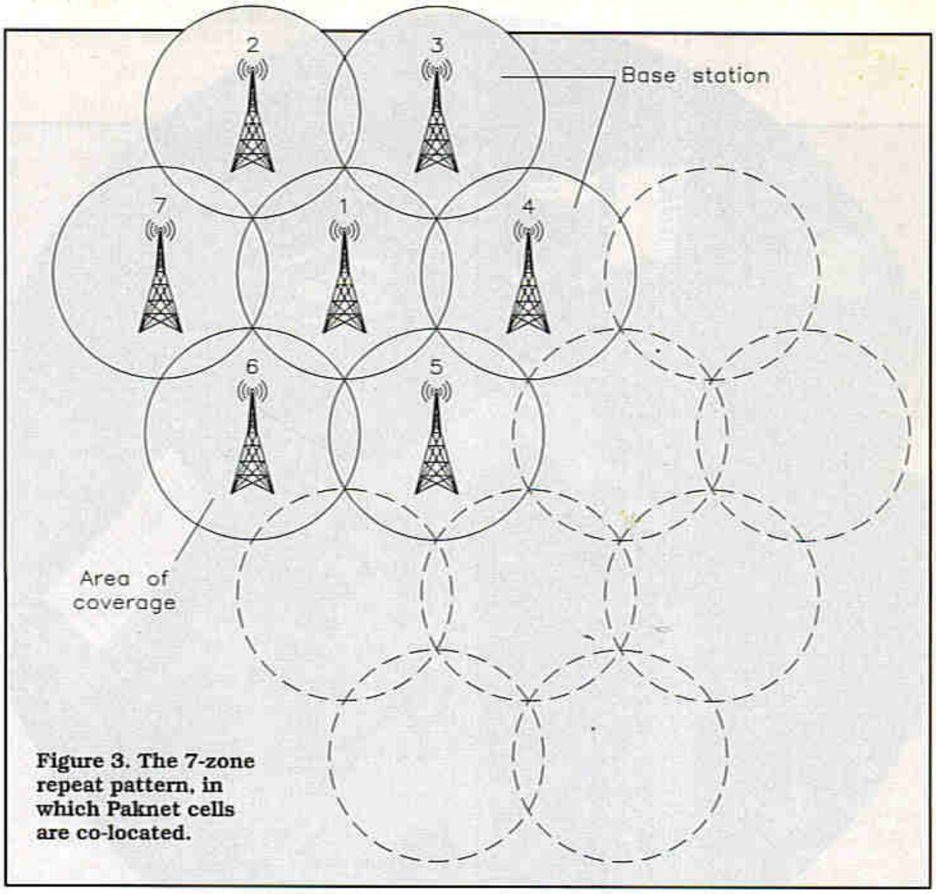


Figure 3. The 7-zone repeat pattern, in which Paknet cells are co-located.

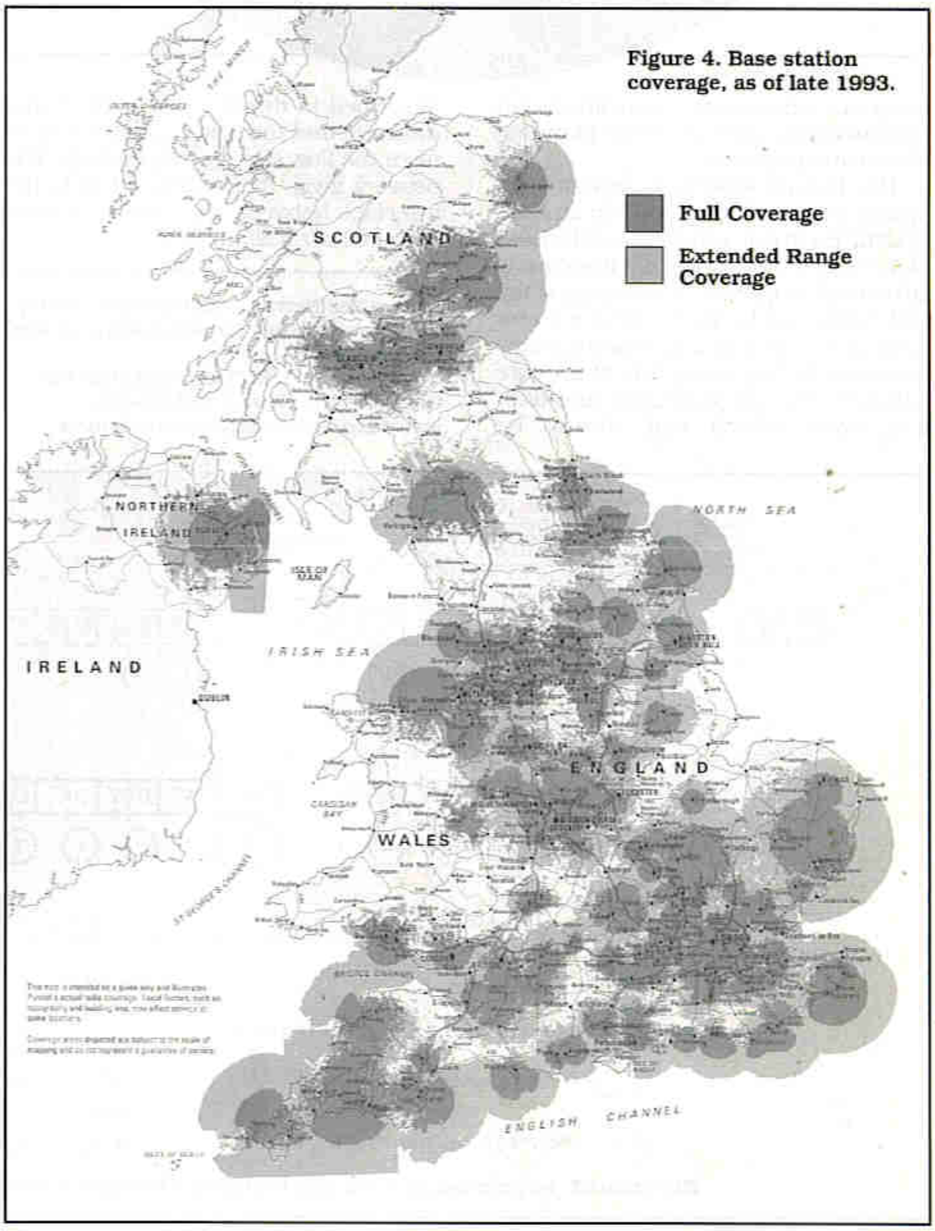
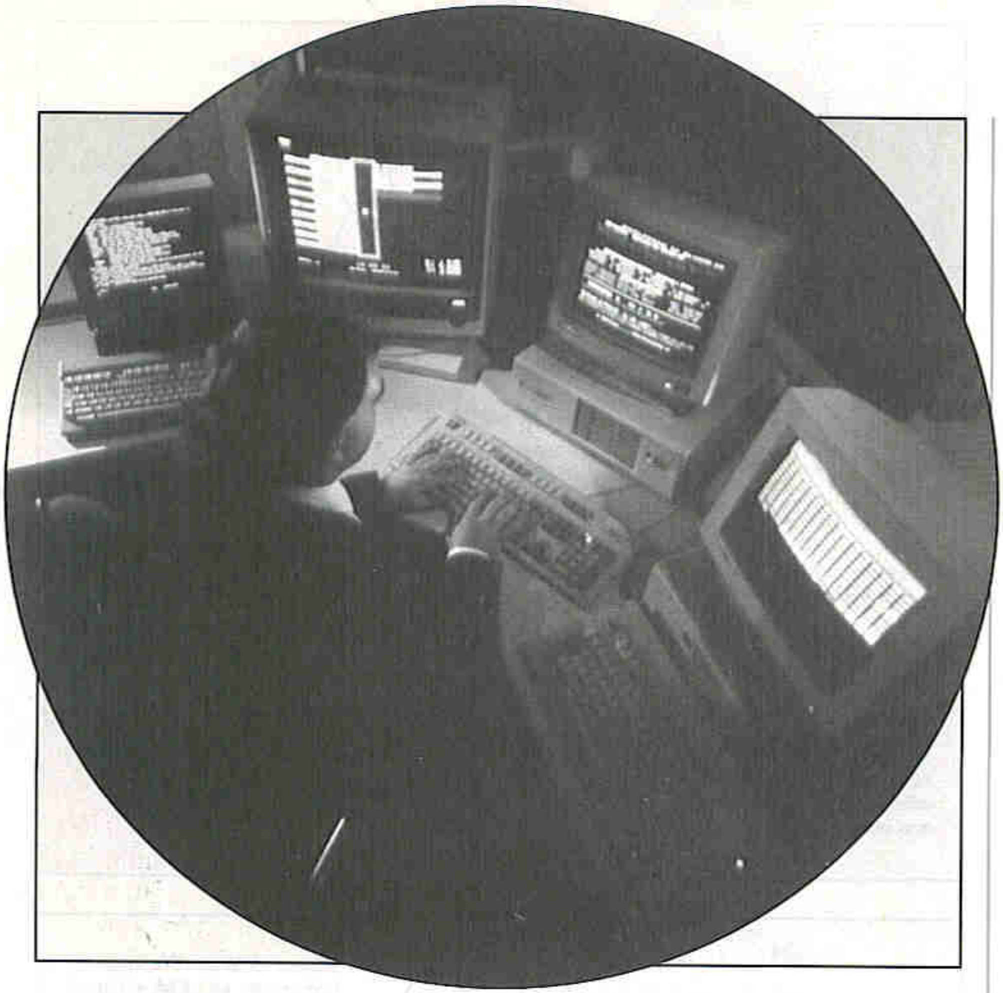


Figure 4. Base station coverage, as of late 1993.



services, help services, registration, and statistical monitoring (for the planning of future expansion).

The Paknet system is designed to appear as just another node on an X.25 system. Each cell, consisting of the base stations and radio pads that it serves, is structured as the first three layers of the OSI 7-layer model. Each of these layers – physical, data link and network, maps across to the X.25 structure of the core network. The physical layer and data link layer, which will shortly be described in detail, refer to the radio medium, and the system that synchronises the flow of data, respectively. The network layer, meanwhile, refers to the interface between the Paknet system and the host X.25 network.

Above: The Network Management Centre (NMC), responsible for monitoring, control and billing.
Below: Figure 5. DSRA coding structure. Note that the forward and reverse structures are divided up into frames.

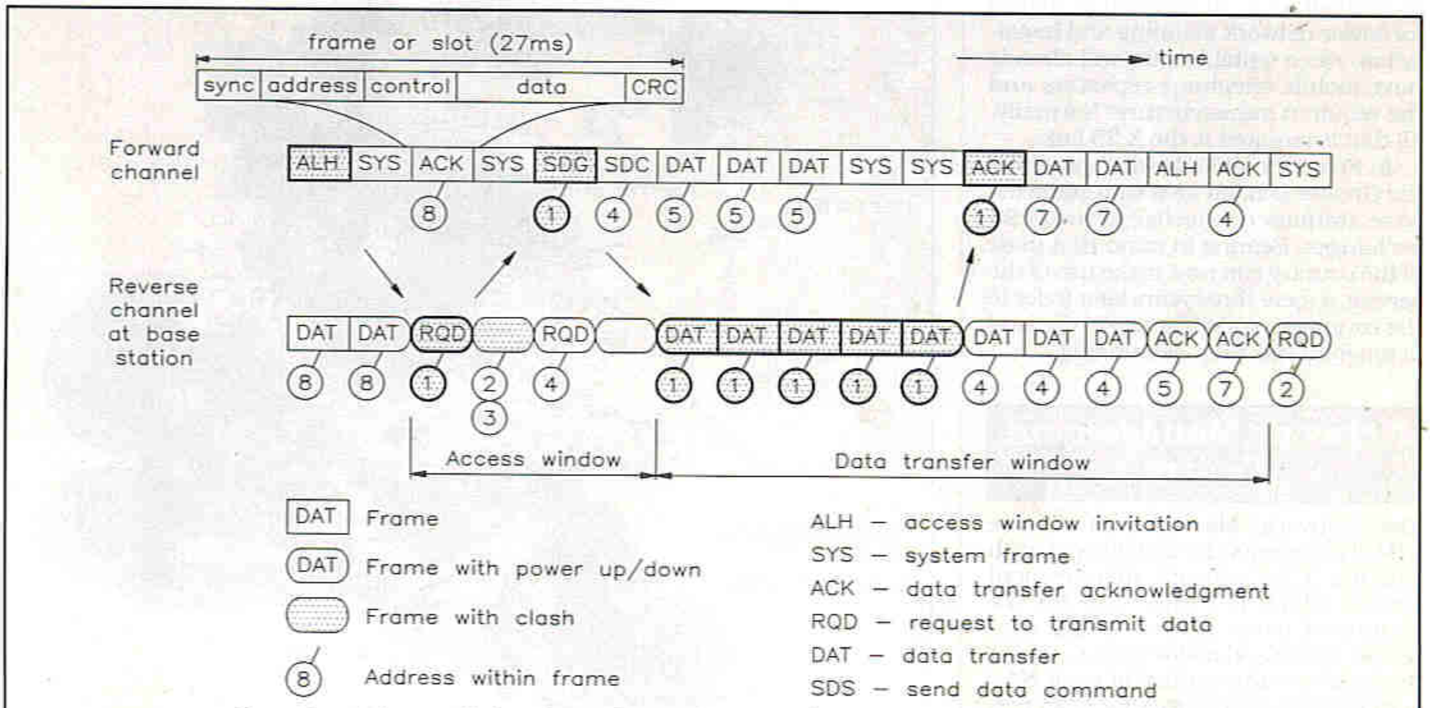
Physical Layer

Paknet, as implemented in the UK, makes use of the VHF band (the Paknet frequency allocation is between 136 and 174MHz). In other countries, UHF (403 to 470MHz) is available as an option, which makes for smaller and less obtrusive aerials. Such frequencies cannot be used in the UK as this area of the band is already fairly crowded – it's taken up by government/military radio, the amateur 70cm allocation, PMR and public service communications.

A channel bandwidth of 12·5kHz was deemed suitable for the system, as it provides the optimum compromise between adequate response time and spectrum usage. The modulation system is FSK (frequency shift keying), mainly because it is simple to implement.

Data Layer

The second layer is concerned with the provision of an error-free service, dealing with link access and management, error correction and synchronisation. Within each cell, the radio pads share a physical channel pair, consisting of forward and reverse channels. The forward channel is under complete supervision of the base station, and is used to transmit control information to the radio pads within the cell. On the other hand, the reverse channel has to be shared by all those radio pads, and consequently, a protocol must be introduced to avoid contention. For Paknet, a new data link layer protocol known as DSRA (Dynamic Slotted Reservation Aloha) was developed. A simplified example of the DSRA coding structure is shown in Figure 5.



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In this system, forward and reverse channels are divided into time slots ('frames') of fixed size. Each frame is a block of data that can be comprised of any of several fields, depending on its purpose – such as synchronisation, control, address, error protection and user information. The radio pad monitors the forward channel frames from the base station and uses them to acquire synchronisation.

Each radio pad competes for the allocation of channel resources using a random access protocol and, if successful, is assigned an independent variable-sized data transfer window within the reverse channel. A control frame sent by the base station defines the slots to be used; if the radio pad already has data ready for transmission, it picks a slot within the access window at random and transmits a request frame. The base station will then reserve the resource and return an acknowledgment to the radio pad, which is used as a cue to send the data. The advantage of DSRA is that of flexibility – considerable efficiency can be achieved even with mixtures of long and short data packets.

Security is well catered for with Paknet, since each radio pad has a unique identification code, and is thus individually accessible. This, coupled with the system's packet nature, means that the chance of intercepting data to which you are not entitled is practically impossible, unless you have an extremely fast logic analyser – and a brain to match! In addition, three levels of error correction help to make the system robust under marginal conditions.

Typical base station site.

Who Uses Paknet?

For many applications, Paknet has proved an ideal choice – the security industry, in particular, welcoming the system with open arms. Two major companies, Chubb (another member of the Racal group), and Modern Alarms, have pledged their allegiance to Paknet.

Traditionally, large alarm systems are connected to a monitoring service via a telephone line. When an intruder triggers a sensor, the alarm automatically dials the preprogrammed number of the monitor, who will then take the appropriate action. Unfortunately, this system is extremely vulnerable – after all, phone lines can be cut. The unobtrusive aerial of the Paknet radio pad can be installed inside the building; by the time the intruder has broken in, the monitoring service knows all about it.

The second advantage is that of speed. There is often a crucial delay (normally between 20 to 30 seconds) between alarm activation and the monitoring service taking action – caused by dialling and providing identification information – this provides the intruder with additional time to fulfil his objective, or enough time to disable the alarm system altogether! With Paknet, this delay is reduced to less than two seconds. Since each radio pad has an ID code, the premises can be located immediately.

Several convictions have already been made as a result of the reduced delay and extra security that Paknet provides.

The End of the Check-out Queue as we Know It?

One of Paknet's first applications (indeed, one for which the system was originally developed) is the world of retailing. Hands up those of you who constantly glance at your watch, while waiting for somebody at the front of the check-out queue to have his credit card checked! But then, of course, you're paying via credit card as well, aren't you? "I don't know, everybody seems to be using credit and debit cards these days!"

The vulnerability nature of 'plastic money' means that safeguards need to be implemented by those who run such services. The best known example of this is the authorisation procedure, which is responsible for the everyday problem outlined above. In modern systems, an EFTPoS terminal, connected to a PSTN line via a modem, dials up the card operator's mainframe and runs a credit check, as well as finding out whether the card has been reported as a stolen one. For those stores not touched by the wand of computerisation, sales staff still make similar credit check enquiries, albeit verbally. Everybody would agree that these measures are very desirable, but it does take such a long time – three minutes is not uncommon, especially during peak periods when free lines are like gold dust. Recognising the need for quicker customer service, the credit checking systems used by other stores are off-line, so up-to-date records on stolen cards are not available, increasing the chance of fraud.

Fear not, Paknet is coming to the rescue. If the EFTPoS terminal is hooked up to a radio pad, the delay is reduced to around six seconds (no engaged lines to worry about) allowing a quicker service to be provided for the customer. Of course, since the system is on-line, the likelihood of card fraud is greatly reduced. Not surprisingly, this application of Paknet is a steady growth area. Paknet also helps behind the scenes, allowing more responsive inventory management systems to be introduced.

Telemetry

An area in which Paknet excels is that of logging data in real-time, particularly where site visits are impractical. If a specific quantity (e.g. traffic, chlorine levels in water or electricity consumption in a particular area) needs to be instantaneously monitored, a dedicated line would have to be installed between the data logger and the site of analysis. In some areas, a leased line can be set up – but what about remote locations, which might not even have an electricity supply? And if there is no option but to install a dedicated circuit to an outlying region regardless of cost, how will it stand up to severe environmental conditions like flooding?

Since Paknet is a wireless system, no lines are required. DC operation means that mains power is not essential, and there are no dial-up delays to worry about. Since no part of the system is exposed to the elements (save the aerial, of course), the system is impervious to bad weather. And, since data can be sent whenever it is required, the system works in real time. These benefits, together with the tremendous cost advantages, add up to even greater success for Paknet.

A potential growth area for Paknet is that of the electricity industry. Thanks to deregulation, companies that consume more than 1MW of power can

Continued on page 22

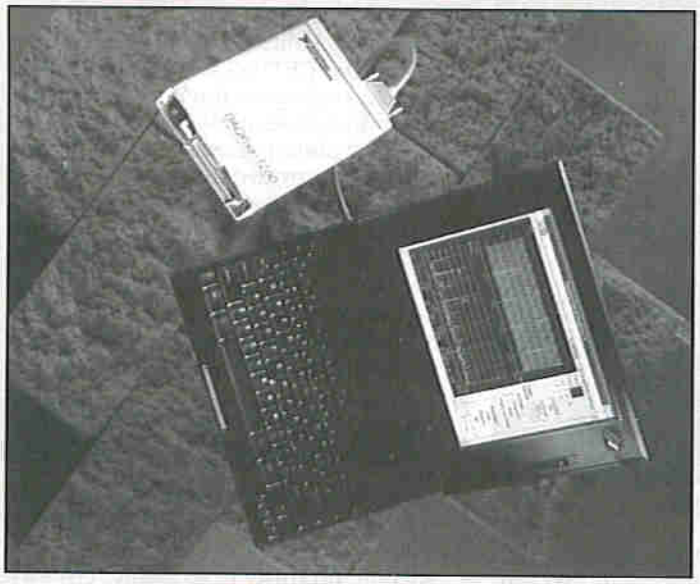
NEWS Report

Notebook PC Data Acquisition

National Instruments has announced a high-performance, compact, lightweight, external data acquisition (DAQ) box. System developers can use the DAQPad-1200 to create portable, flexible data acquisition and control systems.

The DAQPad-1200 is compatible with any PC that has a parallel printer port, making it ideal for PC-based DAQ applications involving laptop and notebook PCs.

The DAQPad-1200 includes an AC adapter to supply power from a 120 or 220VAC wall outlet. An optional battery pack with charger will power the DAQPad-1200 for 9 to 13 hours. Contact: National Instruments, Tel: (0635) 523545.

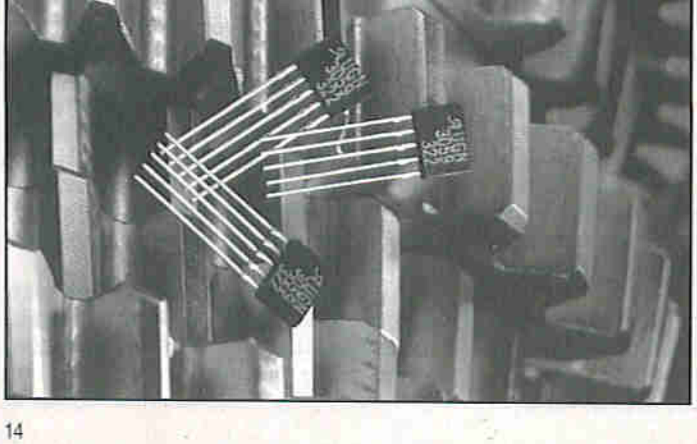


AC-Coupled Hall-Effect Gear-Tooth Sensor IC

A new AC-coupled Hall-effect gear-tooth sensor IC that switches in response to changing differential magnetic fields created by moving ferrous targets has been introduced by Allegro MicroSystems.

The new 3059 is ideally suited to non-zero-speed sensing of speed, position and time. It incorporates a voltage regulator, two quad Hall-effect sensing elements, temperature compensation circuitry, a low-level amplifier, bandpass filter, Schmitt trigger and an open-collector output driver.

In operation, the circuit is coupled with a back-biasing magnet, and can be configured to turn on or off with the leading or trailing edge of a gear tooth or slot. Changes in fields on the magnet face caused by a moving ferrous object are sensed by the two Hall transducers and are differentially amplified by the on-chip electronics. Contact: Allegro MicroSystems, Tel: (0932) 253355.



Robo Owls Stalk the London Skyline

Westminster Council in London has purchased ten battery-operated plastic owls to frighten off the hoards of pigeons whose droppings foul the pavements and monuments of central London's tourist district.

At first, officials tried using stationary replicas positioned at intervals along the parapets of buildings. London's 'streetwise' pigeons were not impressed, demonstrating their distaste in the traditional manner.

Fear not, from initial reports it seems that the motorised owls are a greater success than their static cousins. But for how long?

BT Standardise on Emergency Number

A new emergency number (112) is now operating alongside the usual 999 in the UK. It will put you in touch with such services as police, ambulance and fire brigade and is being phased in throughout the European Union (EU). This is so that a common number is available wherever you go, in line with parts of Europe and the USA. There are no plans to scrap 999.

Engineering Organisation Pledges Increased Co-operation

At the Audio Engineering Society's (AES) 96th Convention in Amsterdam at the beginning of March, ties with Technical Committee TC84 of the International Electrotechnical Commission (IEC) – the body responsible for international standards in the electricity and electronics industries – were considerably strengthened. Joint meetings were held to discuss digital audio, loudspeakers and the interconnections between equipment, as well as interchanges of information on connector applications and EMC.

The AES has been trying for a number of years to achieve a closer relationship with the IEC, largely as a result of early initiatives from European members. Unfortunately, a number of formal problems of protocol had to be resolved, and these always take a very long time. For example, the AES is an international society, but it is based in the USA. Could this mean that the USA would get two votes in the IEC, or alternatively, would the AES oppose the official US National Committee views on some matters, as expressed by the American National Standards Institute (ANSI)? On the plus side, it is often difficult for people in the USA to participate in standards work because of the way in which it has to be done in that country of large distances and very strict 'anti-trust' laws. The AES route should make participation much easier.

It appears that these problems have now been resolved, with much benefit to the industry, because the Society's own standards will in future be very closely aligned with the international standards, which are adopted by almost all countries as national standards. For example, the much-needed revision of the AES/EBU Digital Audio Interface standard, which is also EBU Tech.3250, IEC958, BS7239 and CCIR Recommendation 647, will take place as a joint venture, which should even prevent any confusing differences in wording between the published standards. Of course, it has to be ensured that the EBU and the ITU/RB (formerly CCIR) do not feel left out!

The importance which the AES attaches to this co-operation can be seen by the invitation extended to IEC TC84 to hold its 1994 Plenary Meeting, together with meetings of most of its Working Groups, with the next AES Convention in San Francisco in November 1994.

WordPerfect Provides Mobile Communication Tools

WordPerfect has unveiled a workgroup computing solution for mobile users, providing them with a variety of ways to send and receive electronic mail, schedule requests and tasks. The WordPerfect Office mobile computing solution allows users to access electronic information contained in WordPerfect Office through WordPerfect Office Remote for both Windows and DOS, two-way wireless technology, paging services, telephone access and public carrier access.

The WordPerfect Office mobile computing solution offers users remote access to: e-mail, calendars and task through WordPerfect Office Remote for Windows and DOS; paging services through Motorola; wireless technology through RAM Mobile Data and Cellular (Cellnet and Vodaphone); the telephone through the WordPerfect Office Telephone Access Server (TAS); and public carriers. Contact: WordPerfect, Tel: (0932) 850505.

IBM High-Temperature Superconductivity

IBM researches have fabricated the first thin films of the high-temperature superconducting material mercury-barium-calcium-copper oxide that exhibits zero-resistance superconductivity.

Scientists at the IBM Research Division's Thomas J. Watson Research Centre, have shown that the films became superconducting at a zero-resistance transition temperature of 124°K (-149°C). Because of their excellent electrical and magnetic characteristics as well as a transition temperature almost as high as for the bulk form of the material, such films are expected to be useful in electronic device applications.

Thin films of other high-temperature superconducting materials are already used in several electronics applications, but they become superconducting at temperatures more than 30°C cooler. Contact: IBM, Tel: (0705) 565339.

BBC Dial-in Time Service

The BBC has introduced a pilot service, whereby computer users with Hayes compatible hardware apd suitable software on their IBM compatible PC, can obtain a highly accurate Time Standard. The BBC Radio Time Standard is based on a pair of Global Positioning System (GPS) receivers working in dual-redundant configuration, together with an MSF Receiver. MSF is a 60kHz Time Standard operated by the National Physical Laboratory.

Time data accurate to within 500µs are passed from the Time Standard to a pair of Leitch Clock System Controllers, connected to the public switched telephone network (PSTN) modems for access by callers. One controller operates on Coordinated Universal Time (UTC), notionally the same as Greenwich Mean Time (GMT), and the other on UK Time-of-Day (TOD), adjusted automatically between BST and GMT. The main application for the service is likely to be the synchronisation of real-time clocks on computers and other electronic equipment. Communication details: callers will require a PSTN modem which can operate at 300 Baud full duplex (CCITT recommendation V21).

Details are available from BBC Engineering Information, which also holds details of software available for automatically synchronising IBM compatible PCs. Contact: BBC Engineering Information, Tel: (0345) 010 313 (UK only) and, Tel: +44 81 752 5040 (overseas).

Mobile Management Package

CS Electronics has launched a mobile services management package called SerMan, designed to enable fast and accurate two-way messaging between service engineers and their base.

SerMan is a fully integrated job dispatch and mobile data system specifically designed for service industries. CS Electronics claims the system will dramatically improve customer services by ensuring that service calls, customer data and engineers are properly managed.

Messages are carried via the Paknet Radio Network. This nationwide digital radio network ensures that information is exchanged in seconds and is error free. Messages arrive in text form, eliminating the problems and high call charges associated with voice base systems. Contact: CS Electronics, Tel: (0782) 564564.

Testing Fruit Juice

A technique developed at the University of Nantes in France, to certify the authenticity of French wines, is now being used to determine whether fruit juices reach their mark.

The Snif-NMR technique determines whether sugars in the juice come from fruit or sources such as sugar beet or cane.

Eurofins, the Nantes-based company which carries out the process, ferments the sugar into alcohol. Magnetic resonance is then used to determine the overall ratio of hydrogen and deuterium (the heavy hydrogen isotope) in the alcohol. The ratio varies according to the type of sugar, indicating whether it is naturally occurring or has been added during processing.

The process also identifies where the carbon atoms in the alcohol are sited, a further indicator of the purity of the orange, apple, grapefruit or pineapple juice. Contact: French Technology Press Bureau, Tel: (071) 235 5330.

18-Bit Bidirectional Buffer

Integrated Device Technology's (IDT) new 18-bit bidirectional buffer is ideal for use with today's high-speed processors. With a 5·5ns propagation delay, the FCT162701T solves the bandwidth mismatch problems between interfaces with speed differentials, such as CPU-to-memory or CPU-to-I/O in R4400/R4600, Pentium and PowerPC applications. The FCT162701T combines the functionality of two transparent octal latches and an 18-bit wide, 4-bit deep FIFO into a single compact 56-pin part. Compared to the equivalent discrete implementation, IDT claims it saves over 80% in board area, reduces part count by eight-to-one and simplifies board layout.

The FCT162701T is available in 330 mil-wide, 25 mil-pitch 56-pin SSOP and in 240 mil-wide, 20 mil-pitch 56-pin TSSOP. 5·5ns and 6·5ns speed grades are available. Contact: Integrated Device Technology, Tel: (0372) 363734.

Virtual Working Environment

A consortium of UK industrial and academic partners, led by BT, is collaborating on a project that aims to create a 'computer-generated' environment where users can work with each other, regardless of location.

Using virtual reality to support co-operative work across dispersed groups, Virtuosi will allow people to join discussions and problem-solving activities at home or in different offices or factories across the world.

Two pilot services will be developed for the project. One will be concerned with improving communication between a number of BICC cable factories throughout the world. The aim is to enable managers and works to co-operate as if they worked in a single factory. For example, experts will be able to 'visit' shopfloor staff on another continent to resolve technical and production issues at the remote factory.

Expertise from the UK company, Division, will contribute to the core framework of the project, providing powerful tools to allow users to interact within the virtual environment. BT Laboratories and GPT will be involved in developing the telecommunications aspects of the project. GPT's contribution will also be supported by GEC Marconi Hirst Research Laboratories which has considerable experience in distributed virtual reality applications.

A strong theoretical basis will be provided for the project by Nottingham, Lancaster and Manchester Universities. These universities are all involved in UK and European Research projects to establish the fundamental principles for interacting and co-operating in virtual environments that will be set up across future information superhighways. Besides developing models and systems, they will also be involved in user requirements, capturing and assessing the effectiveness of the two application pilots. Contact: BT Laboratories, Tel: (0473) 647448.

Young Amateur of 1994

For the seventh year running, the RSGB has announced the Young Amateur of the Year Award which is again being sponsored by the Radiocommunications Agency (RA) and the communications industry.

The prestigious award, initiated by the RSGB in 1988, is open to anyone under the age of 18 who has an interest in amateur radio. It is awarded for the most outstanding achievement by a young radio amateur who need not necessarily be a licence holder.

In addition to the coveted title, the winner will be presented with a £300 cash prize, a Sony general coverage receiver, and a one week residential course at Wray Castle College in the Lake District. The runner-up will receive a hand-portable transceiver, a £25 book token and a multimeter. All entrants will be given a copy of an RSGB book.

The closing date for nominations is 31 July. Forms can be obtained from Justine Hodges, RSGB, Lambda House, Cranbourne Road, Potters Bar, Hertfordshire EN6 3JE.

Maplin Helps Multi-Action Security

For Graham Perks, chief electrical instructor, Electronics Department, North East Micro Centre, North Shields (Brass Tacks), the call from the local Multi-Action Crime Prevention Initiative was most opportune. The Action Group, a police liaison unit, wanted Brass Tacks to help design and implement a security system to assist its fight against crime for the community.

"Our brief", said Mr. Perks, "was to provide a low cost camera monitoring device; one which could easily be fitted into houses, particularly those occupied by elderly people, who needed to see who was at their front door. There was also a requirement for a security camera in local schools to help prevent vandalism. Cabling in all cases was to be avoided with radio providing the possible solution."

The chosen system was based on the Maplin CCD sub-miniature video camera with the video converted to a radio signal and then fed to a standard TV or VHS video recorder.

The low running voltage and dependability coupled with low price are much appreciated by Brass Tacks with plans to purchase at least a further 200 CCD video cameras from Maplin. At present the 25 unit project is very much seen as an experiment. Four potential applications have already been clearly identified – Camwatch, a portable home video security link; the door entry video; the passive infra-red sensor/security light; and a garage alarm. Further projects are in the pipeline. Contact: Graham Perks, Tel: (091) 258 0533.

DIARY DATES

Every possible effort has been made to ensure that information presented here is correct prior to publication. To avoid disappointment due to late changes or amendments, contact event organisations to confirm details.

3 May. Magnetic Loop Aerials – Operating Evening and Talk, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

5 to 6 May. International Conference on Adaptive Search and Optimisation in Engineering Design, Institution of Electrical Engineers, London. Tel: (071) 344 5446.

10 to 12 May. Expo-Lab 1994, Laboratory Technologies Exhibition, National Exhibition Centre, Birmingham. Tel: (081) 302 8585.

10 to 12 May. Control & Instrumentation Exhibition, National Exhibition Centre, Birmingham. Tel: (081) 302 8585.

11 May. Annual General Meeting, Lincoln Short Wave Radio Club, Lincoln. Tel: (0427) 788356.

15 May. Radio Society of Great Britain, National Exhibition Centre, Birmingham. Tel: (0707) 59015.

15 May. National Vintage Communications Fair, National Exhibition Centre, Birmingham. Tel: (0398) 331532.

15 May. Special Event Station, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

18 May. Japanese Morse by Norman Kedrick, Lincoln Short Wave Club, City Engineer's Club, Waterside South, Lincoln. Tel: (0427) 788356.

19 May. Lecture on EMI's digital re-issues on CD by Andrew Walter of Abbey Road Studios, 6.45pm National Sound Archive, 29 Museum Road, London. Free tickets by arrangement. Tel: (071) 323 7760.

21 May. Fibre Optics by A. Ogden, Crystal Palace & District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: (081) 699 5732.

21 to 22 May. International Kite Festival with Kite Aerials, Wireless Museum, Puckpool Park, Seaview, near Ryde, Isle of Wight. Tel: (0983) 567665.

25 May. Trip to Guildhall, Lincoln Short Wave Radio Club, Lincoln. Tel: (0427) 788356.

6 June. D-Day Commemoration Display, with working transmitters and receivers from the war, Wireless Museum, Puckpool Park, Seaview, near Ryde, Isle of Wight. Tel: (0983) 567665.

7 June. Using Integrated Circuits, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

8 June. Junk Sale, Lincoln Short Wave Radio Club, Lincoln. Tel: (0427) 788356.

14 to 16 June. Multimedia 1994, Earls Court 2, London. Tel: (071) 742 2828.

15 June. Walking Treasure Hunt, Lincoln Short Wave Radio Club, Lincoln. Tel: (0427) 788356.

18 June. Electromagnetic Compatibility (EMC), Crystal Palace & District Radio Club, All Saints Parish Church Rooms, Beulah Hill. Tel: (081) 699 5732.

19 June. Special Event Station in Halstead, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

19 to 24 June. Unipede – Electricity Conference, ICL, Birmingham. Tel: (081) 743 3106.

20 June. Electrotech, National Exhibition Centre, Birmingham. Tel: (0483) 222888.

25 June. Special Event Station at Great Cornard Middle School, Sudbury and District Radio Amateurs. Tel: (0787) 313212.

27 to 29 June. 5th Satellite Systems for Mobile Communications & Navigation Conference, Institution of Electrical Engineers, London. Tel: (071) 240 1871.

Please send details of events for inclusion in 'Diary Dates' to: The News Editor, *Electronics – The Maplin Magazine*, P.O. Box 3, Rayleigh, Essex SS6 8LR.

2
PROJECT RATING

COMPLETE KIT AVAILABLE (LT57M)
Price £19.99

LIVE WIRE GAME

by Joe Fuller

Features
* Lives indicator
* Low voltage operation
* Easy to build

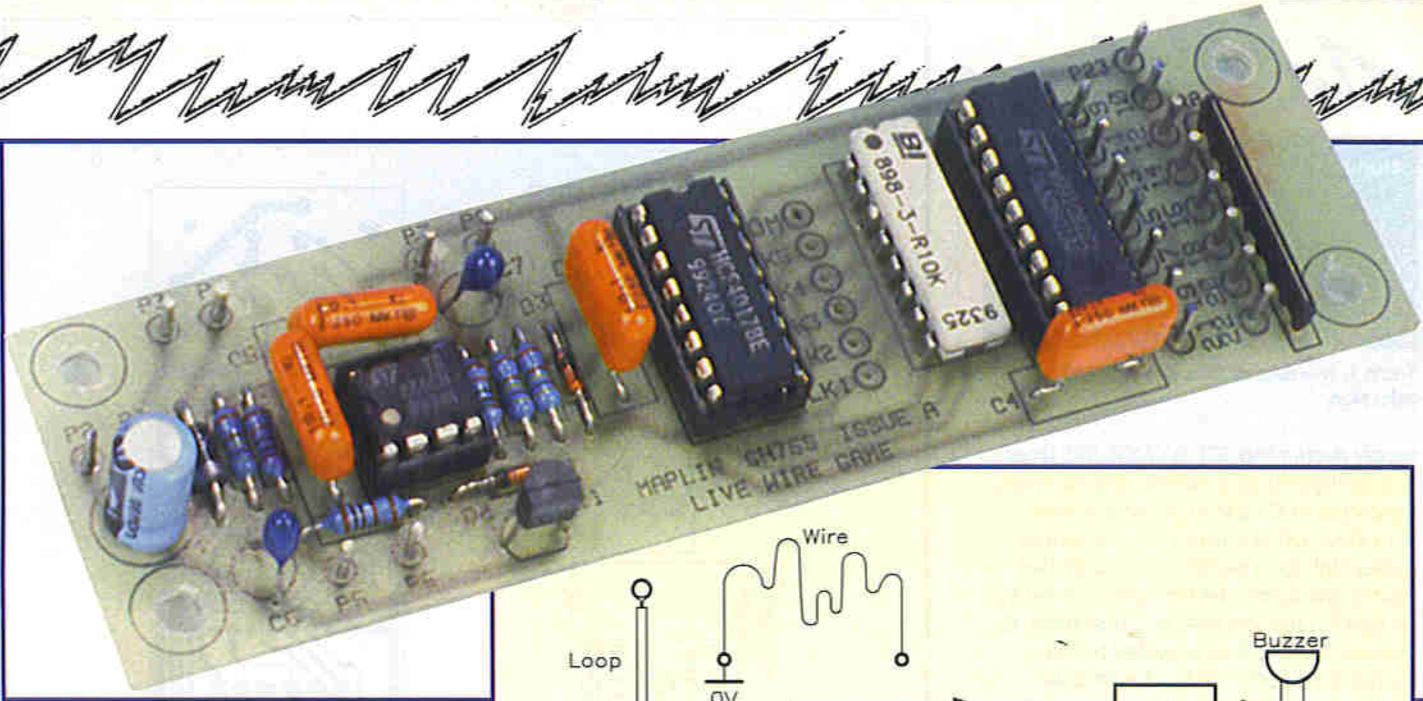
Applications
* Fund-raising events
* Family fun
* Reducing stress
* Improving hand/eye co-ordination

The idea behind the Live Wire Game is not a new one; in fact many designs for such games have been published in the popular electronics press over the years. Such games are often seen at fund-raising events such as Church and School Fêtes. It may be that if you are known to the Parent-Teacher Association as being electronically minded, you might get talked into the job of designing and building such a unit. However, help is at hand (at least from the design point of view) with this latest variation on the traditional theme.

FOR the benefit of those that have lived a sheltered life and have not encountered one of these games before, the idea behind this project is quite simple.

The contestant is faced with an awkwardly shaped length of 'live' wire, more reminiscent of a twisting mountain path than an electrical conductor, along which a small metal loop attached to a handle has to be carefully passed, from start to finish. The only snag being, is that the loop must not touch the 'live' wire. If the loop does make contact, a bell (or other device) sounds, so alerting the world to the failed attempt. It is usual to pretend that the live wire is at some dangerously high potential to add some excitement to the proceedings, of course in reality only some six to twelve volts are present.

However, these traditional games often suffer from a few shortcomings. First, there is often no clear indication when the loop makes just momentary contact, this can often lead to arguments as to whether the loop made contact or not. Second, the contact between loop and wire usually carries the bell current directly and if there is any appreciable contact resistance the bell may not sound properly. Third, differing abilities can mean that it is difficult to provide an interesting game for a wide range of contestants. Too easy, and too many prizes will be won, too hard, and too many people will 'fall at the first hurdle'; the result can be a lack of interest to have another go.



Close-up of the completed Live Wire Game PCB.

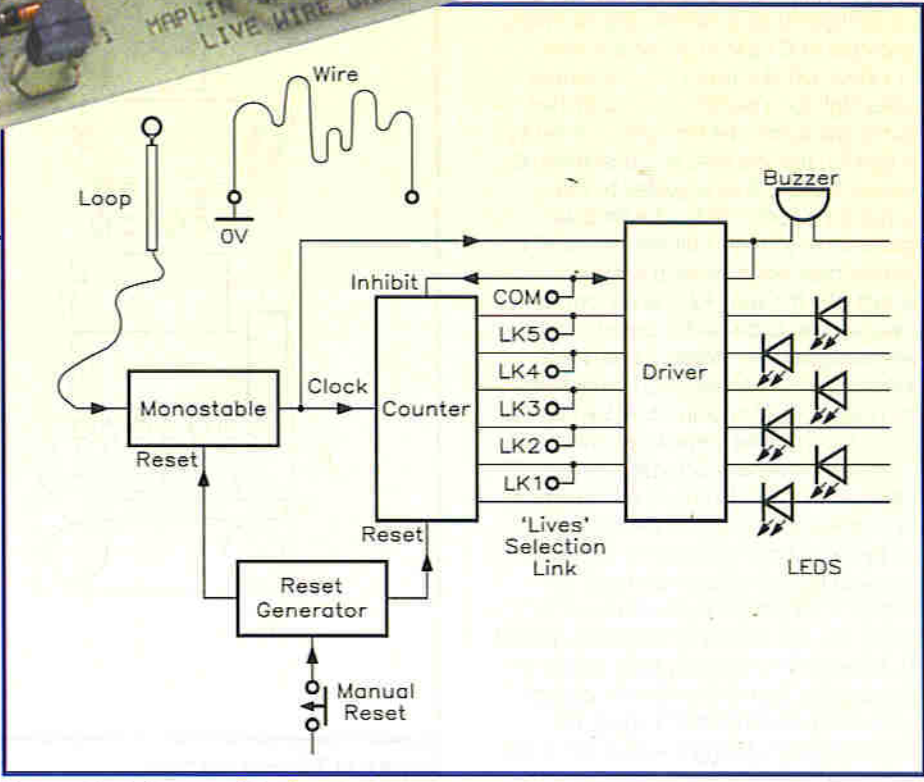


Figure 1. Block diagram of the Live Wire Game.

Specification

Base Unit Dimensions:	298 X 56 X 172mm (excluding loop)
Supply Voltage:	+9 to +16V DC
Supply Current:	50mA max @ 12V

The design presented here includes some simple electronics to overcome the problems mentioned above, and add a little more excitement. Whenever contact is made between the loop and the wire, a buzzer sounds, the minimum duration of which is governed by a monostable. Using this approach ensures that even the briefest contact is clearly registered, so avoiding arguments or cheating. Contact resistance will prove less of a problem, since the loop current required to trigger the monostable is quite low. Contact resistance as high as several kilohms will still trigger the monostable. Interest is added by providing 'lives' such that the contestant has, say, three lives to make it from start to finish. Indicators count off the 'lives' as they are lost, once all lives have been expired a lost indicator illuminates and a buzzer sounds continuously. The design presented here allows the number of lives to be set between one and five.

As the project stands, LEDs or filament lamps can be directly driven. If desired, relays could be employed to drive heavier loads. For safety reasons, it is inadvisable to use the unit to switch mains voltage indicators by any method.

Circuit Description

Figure 1 shows the Live Wire game in block diagram form, whilst Figure 2 shows the actual circuit. Power is applied to the module via P1 (+V$_{IN}$) and P2 (0V$_{IN}$), S1 (wired to P3 and P4) is the power switch. D1 serves as polarity protection should the supply to the Live Wire Game be inadvertently reversed. C1 to C4 provide

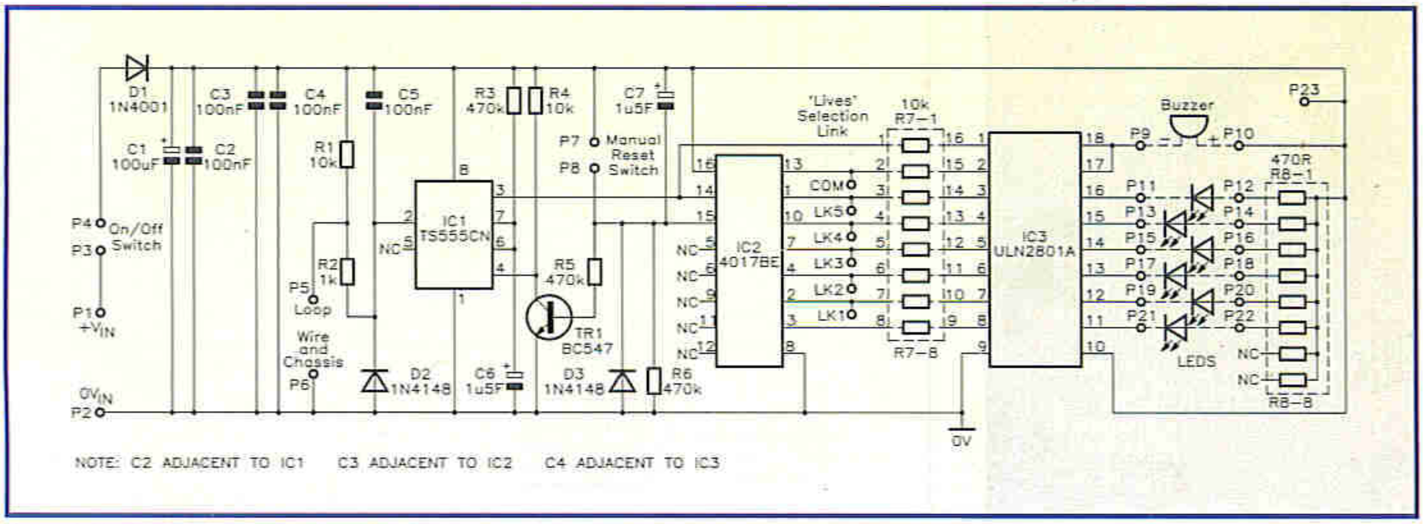


Figure 2. Circuit diagram of the Live Wire Game.

Number of Lives	Fit Link
5	LK5 to COM
4	LK4 to COM
3	LK3 to COM
2	LK2 to COM
1	LK1 to COM

Table 1. Number of lives and PCB link selection.

supply decoupling. IC1, a CMOS 555 timer IC is configured as a monostable. Normally, the output of IC1 (pin 3) is low, but when IC1's input (pin 2) is taken low, the output pulses high for a period of time and then returns low again. The time period is set by C6 and R3. The 'live wire' is connected to 0V (P6) and the loop that is guided by the contestant is connected to the module's input (P5). R1 ensures that the input to IC1 remains high when the loop is not in contact with the wire. R2 and C5 form a low-pass filter to prevent radiated electromagnetic interference from false-triggering IC1. D2 prevents IC1's input pin from being pulled negative by C5 when the power supply to the game is removed. IC2, a CMOS 4017 decade counter, has ten outputs, and is used to count off the lives of the contestant. Only one of the ten outputs can be high at any one time. In this circuit only six of the ten outputs are used. At switch on, IC2 is reset by the action of C7 and R6. R5, TR1 and R4 simultaneously reset IC1. S2 is used to manually reset the game, thus avoiding the need to turn the power switch S1 to off and then on again. D3 prevents C7 from taking the reset pin of IC2 negative when the power to the game is removed. When reset, IC1's output '0' (pin 3) is high, whilst all other outputs are low. Each time the loop touches the 'live wire' a pulse is generated by IC1, which in turn advances

Pin Number	Description
1	+V Supply
2	0V Supply
3	On/Off Switch
4	On/Off Switch
5	Loop Input
6	Wire 0V
7	Reset Switch
8	Reset Switch
9	Buzzer –V
10	Buzzer +V
11	LED 6/Lamp 6 –V
12	LED 6 +V
13	LED 5/Lamp 5 –V
14	LED 5 +V
15	LED 4/Lamp 4 –V
16	LED 4 +V
17	LED 3/Lamp 3 –V
18	LED 3 +V
19	LED 2/Lamp 2 –V
20	LED 2 +V
21	LED 1/Lamp 1 –V
22	LED 1 +V
23	Lamp 1 to 6 +V

Table 2. PCB pin functions.

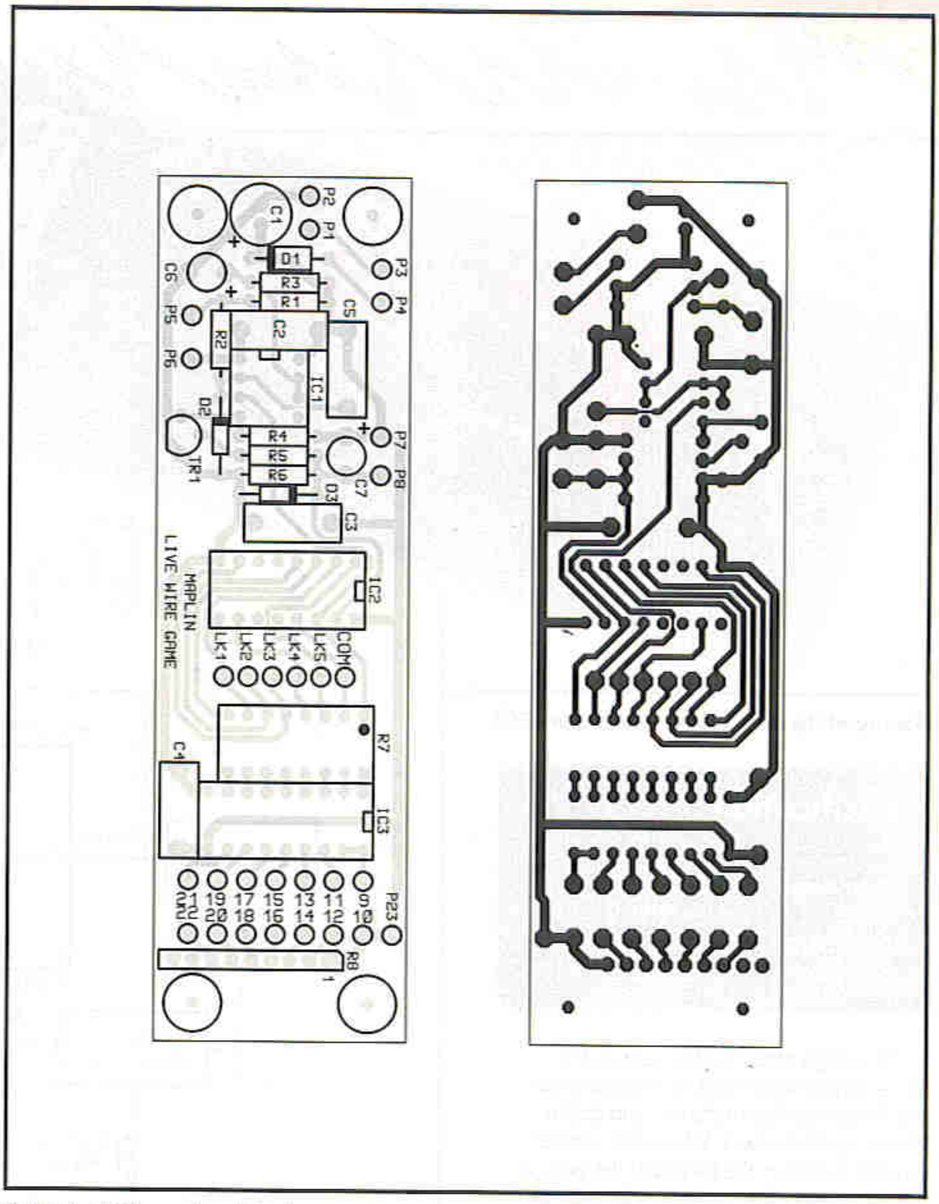
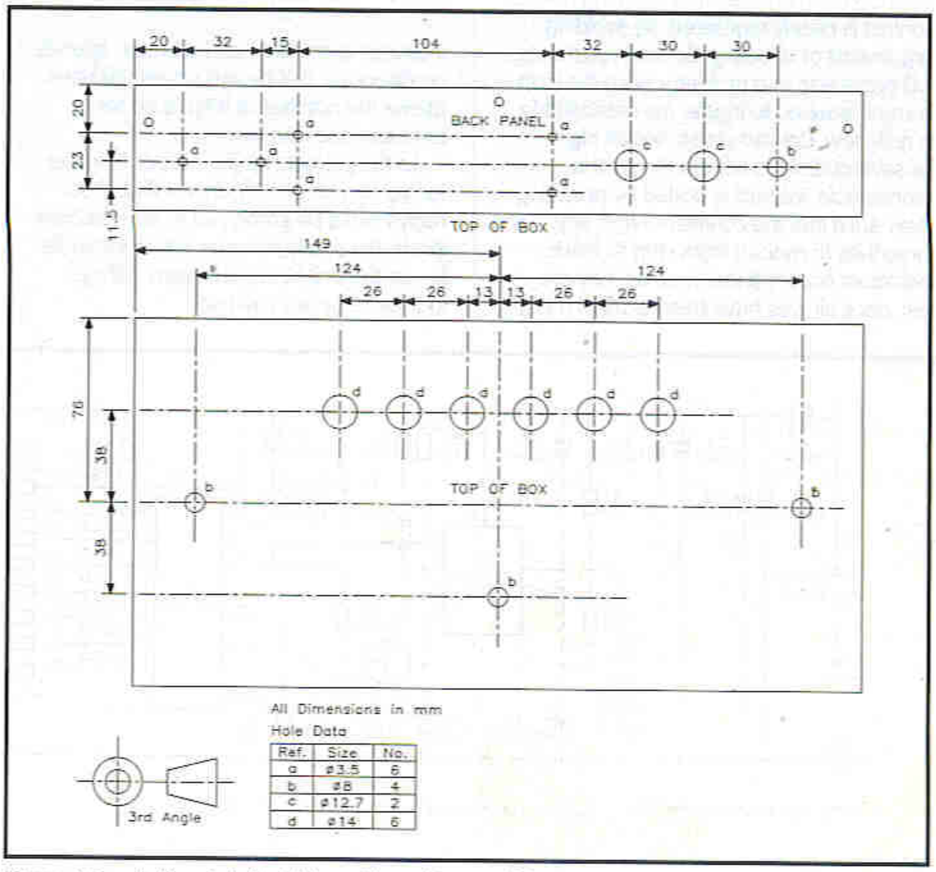
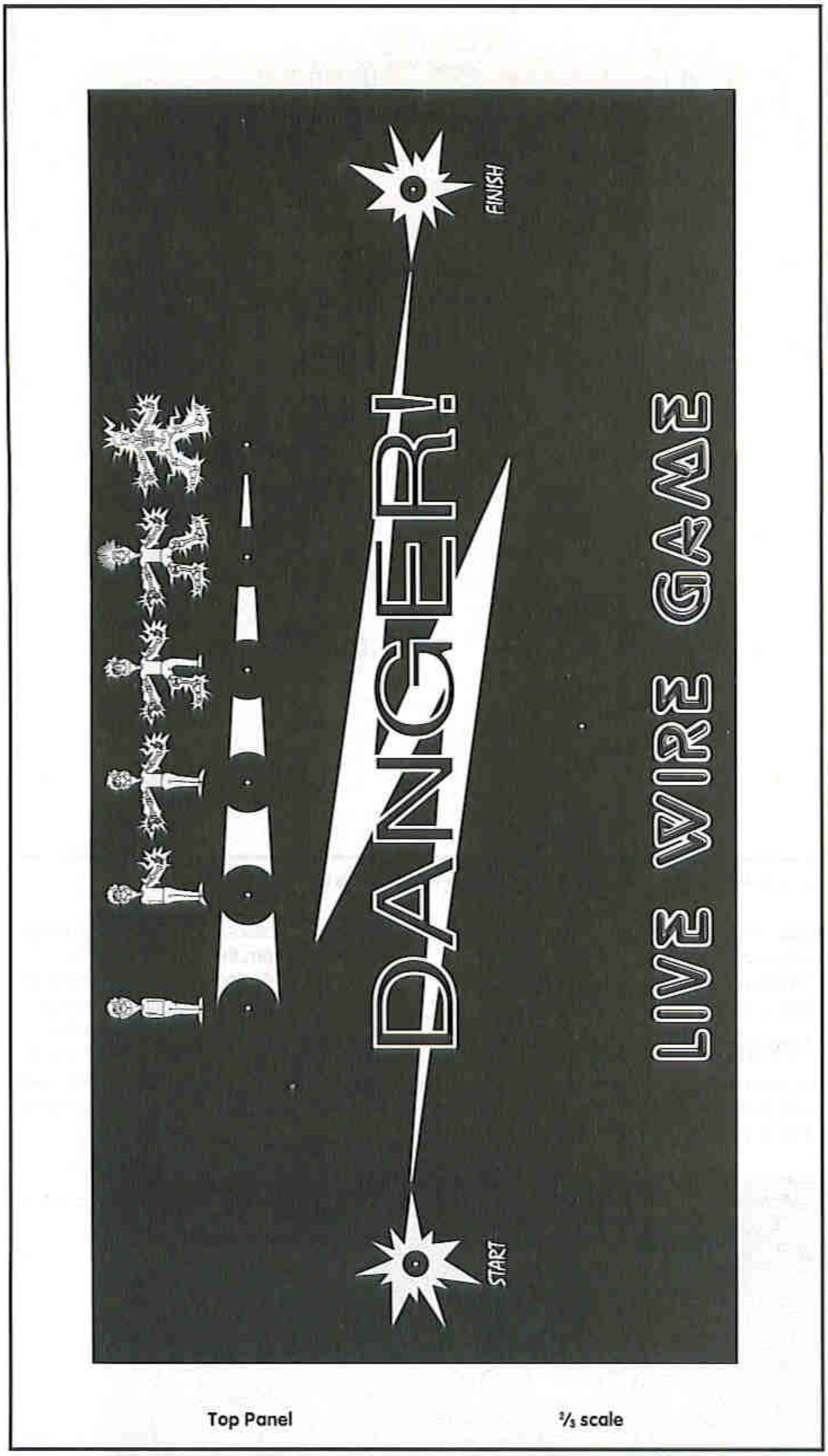


Figure 3. PCB legend and track.



Ref.	Size	No.
a	ø3.5	6
b	ø8	4
c	ø12.7	2
d	ø14	6

Figure 4. Box drilling details: (a) top of box; (b) rear of box.



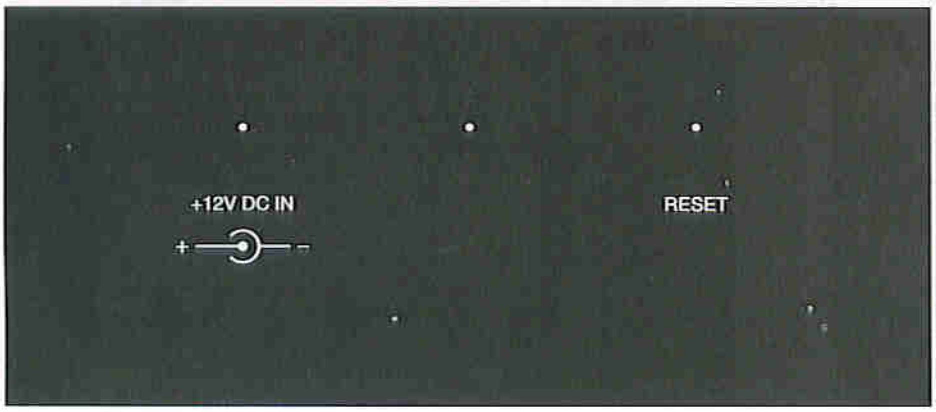


Figure 5. Suggested lettering and graphics for: (a) top of box; (b) rear of box.

the outputs of IC1 and also sounds a buzzer for the duration of the pulse. After one pulse, output '1' (pin 2) is high, whilst all other outputs are low. After two pulses, output '2' (pin 4) is high, whilst all other outputs are low. This action is repeated for each successive pulse, until the contestant 'runs out of lives', at which point the 'lost' buzzer sounds continuously until the S2 is pressed. The number of lives is set by fitting a link on the PCB between one of the pads marked LK1-LK5 and the pad marked COM; the game can be configured for any number of lives between 1 and 5. The link connects one of IC2's outputs to IC2's clock inhibit input (pin 13); which, when high, prevents further pulses from advancing IC2's outputs. IC3 is a Darlington transistor array and is used to provide drive to the 'lives indicators' connected to P11 to P22 and also the buzzer connected to P9 and P10. The indicators may be either LEDs or filament lamps. If filament lamps are to be used, R8-1 to R8-6, contained within an SIL resistor array are not required. R8-1 to R8-6 are required if LEDs are to be used. R7-1 to R7-8, contained within a DIL resistor array, provide drive to the transistors in IC3 and serve to limit base current.

PCB Construction

The PCB legend and track are shown in Figure 3 which will assist assembly. PCB construction should present few problems for most constructors, however, the following suggestions will ensure that construction proceeds smoothly. Absolute beginners are referred to the Constructors' Guide (supplied free with the kit) which offers general guidance on building electronic projects. It is best to insert the components in order of size, starting with the smallest components first, e.g., diodes and resistors, working up to the largest components, e.g., the capacitors. Note that R7-1 to R7-8 are contained within a single DIL package and that R8-1 to R8-6 are contained within a SIL package (R8-7 and R8-8 are unused). Both of these resistor arrays should be fitted so that their pin 1 marks align with the corresponding marks on the PCB. Ensure that polarized devices, such as the diodes, transistors, ICs, electrolytic and tantalum capacitors are correctly orientated. Sockets are recommended for the ICs since this allows easy replacement in case of failure (literally servicing in the *field* in some cases!). Do not fit the ICs until *all* other construction and wiring is complete. Note that IC1 and IC2 are both of CMOS fabrication and the usual precautions to prevent damage caused by electrostatic discharge should be observed. PCB pins are also used to make interwiring easier. The 'lives' link should be fitted to set the required number of game lives. If you are building the kit and using the label supplied, set the number of lives to five.

Once PCB construction is complete, check over your work to ensure that all components have been correctly fitted and that there are no short circuits caused by solder bridges or splashes. A suitable PCB cleaning solution may be used to remove excess flux contamination from the PCB.

Case Preparation

The box supplied in the kit is made of aluminium, and is easy to drill and file with basic metal-working tools. However, sensible precautions should be taken to ensure safety when drilling; wear safety goggles to prevent eye injury caused by hot flying metal swarf. Avoid the temptation to remove metal filings from the box by blowing them out – you could end up with them in your eyes. Keep young children and pets out of the work area. Older children, who are eager to help, should be equipped with suitable safety goggles. All holes should be deburred with a file or a deburring tool.

Figure 4 shows the drilling details for the top and side of the box; no drilling is necessary in the base. The box is supplied covered with a protective plastic film, do not remove this until all drilling and filing is complete, otherwise it will become very badly scratched. The drilling details can be marked on the protective film with a fine tipped indelible pen. A centre punch should be used on all hole centres, which will help prevent the drill bit skidding. The larger holes can be filed out if suitably sized drill bits are not available, but make frequent checks on progress as it is very easy to file out too much metal!

The final appearance of the box can be substantially improved by spray-painting the box before assembly. Aerosol car paints are ideal for this and produce excellent results, if care is taken. Briefly: rub the box down with extra fine abrasive paper; prime the metal surface with metal primer; apply several *thin*, even coats of paint and allow to dry thoroughly before attempting assembly. To really make the unit look good, ready-made labels are included in the kit (and are also available separately). The labels are reproduced in Figure 5.

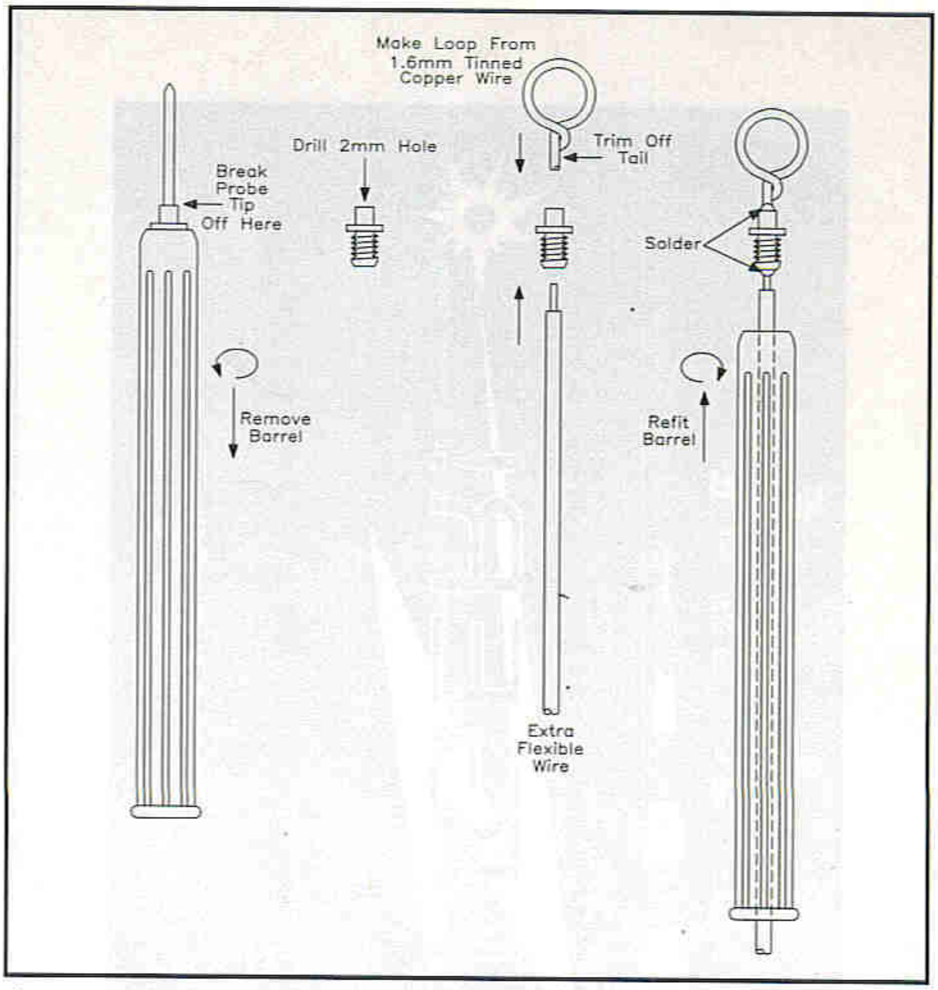
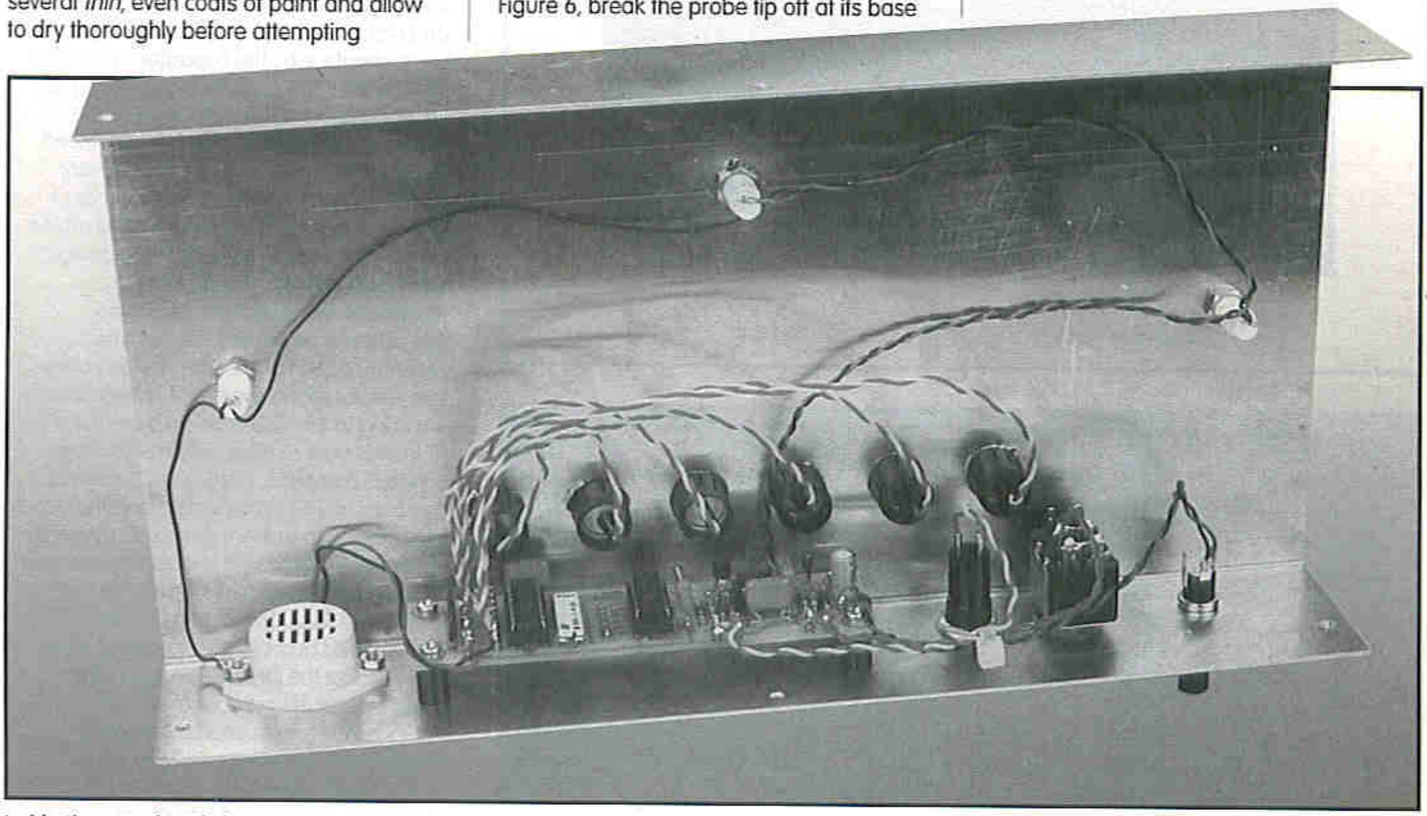


Figure 6. Modification to a multimeter probe to make the loop and handle.

Making the Loop

The loop that is passed over the live wire is made from a multimeter probe. Referring to Figure 6, break the probe tip off at its base with a pair of pliers. Then remove the metal probe insert from the plastic barrel by unscrewing it. Supporting the remainder of the probe insert in a vice, drill a 2mm hole through its centre. Form a loop from the 1·6mm tinned copper wire supplied, use a pencil or similar as a former – the diameter of the loop should be large enough to pass



Inside the completed Live Wire Game.

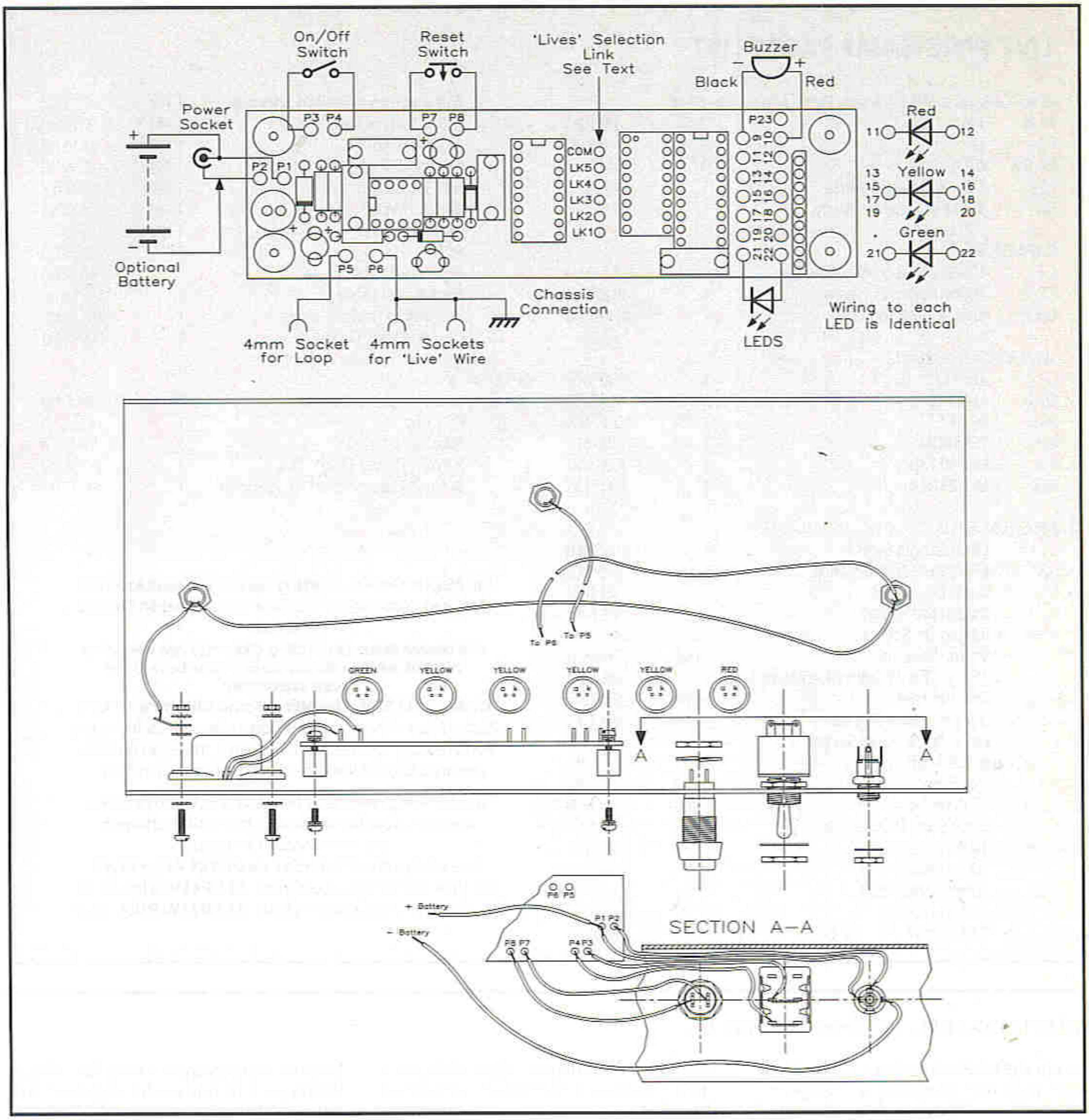


Figure 7. Assembly and wiring diagram.

over the barrel of the 4mm banana plugs. Place the tail of the loop in the hole in the probe insert and solder. Solder the extra-flexible wire onto the other end on the probe insert and refit the plastic barrel. Fit a 4mm banana plug onto the free end of the wire.

Assembly and Wiring

Referring to Figure 7, fit the power socket, switches, sockets, LEDs, and buzzer. Make connections to the PCB with hook-up wire, then fit the spacers onto the PCB. Fit the PCB into the box and secure. The free ends of the wires can be cut to length and connected as shown in the diagram.
The live wire is made from 1·6mm tinned copper wire, bent into a suitably difficult (but not impossible) to follow shape. Since the wire and loop are connected by means of banana plugs, several different 'live wires' can be made to cater for a wide range of skill levels. To give particularly steady handed people a run for their money, place a loop in the wire!

Testing

Apply power to the unit, either from a battery or an AC/DC adaptor and switch on. The first, 'all lives intact' LED (green) should illuminate. After about a second (reset period) bring the loop into brief contact with the wire; the buzzer should sound momentarily and the lives counter decrease by one (yellow LEDs). Repeat this, each time the buzzer should sound and the next LED illuminate. Finally once the 'all lives lost LED' (red) is reached, the buzzer should sound continuously until the reset button is pressed. If all has proceeded as described, the unit is fully functional.

If problems are encountered, recheck all of the wiring to trace the fault. If this still does not resolve the problem, trace through the circuit with reference to the circuit description to see if each stage is operating correctly.

Use

Volunteer to run a 'Live Wire Game' stall at the next School or Church Fête and have fun watching people getting extremely frustrated!

Other Ideas

Build a huge Live Wire Game, using large lamps and a bell instead of the LEDs and buzzer. The driver IC can switch loads of up to 500mA, but for substantially rated loads (12V car filament lamps, etc.) it will be necessary to use relays to switch them. Keep the switched voltage below 50V for safety reasons.

LIVE WIRE GAME PARTS LIST

RESISTORS: All 0·6W 1% Metal Film (Unless specified)			
R1,4 10k	2	(M10K)	
R2 1k	1	(M1K)	
R3,5,6 470k	3	(M470K)	
R7 10k DIL Resistor Array	1	(DL90X)	
R8 470Ω SIL Resistor Array	1	(RA26D)	
CAPACITORS			
C1 100µF 25V Radial Electrolytic	1	(FF11M)	
C2-5 100nF Radial Polyester	4	(BX76H)	
C6,7 1µ5F Tantalum Bead	2	(WW61R)	
SEMICONDUCTORS			
D1 1N4001	1	(QL73Q)	
D2,3 1N4148	2	(QL80B)	
TR1 BC547	1	(QQ14Q)	
IC1 TS555CN	1	(RA76H)	
IC2 HCF4017BEY	1	(QX09K)	
IC3 ULN2801A	1	(QY78K)	
MISCELLANEOUS			
S1 DPDT Toggle Switch	1	(FH39N)	
S2 SP Push to Make Switch	1	(FF98G)	
8-pin DIL Socket	1	(BL17T)	
16-pin DIL Socket	1	(BL19V)	
18-pin DIL Socket	1	(HQ76H)	
1mm Veropins	1 Pkt	(FL24B)	
152 x 51 x 298mm Aluminium Box	1	(KR56L)	
Stick-on Feet	1 Pkt	(FD75S)	
2·5mm Power Socket	1	(JK10L)	
Black 4mm Panel Socket	3	(HF69A)	
Black 4mm Plug	3	(HF62S)	
Test Probe	1 Pair	(FK32K)	
TC Wire 1·6mm	1 Reel	(BL11M)	
Black Extra Flexible Wire	1m	(XR40T)	
10mm Red LED	1	(UK25C)	
10mm Yellow LED	4	(UK27E)	
10mm Green LED	1	(UK26D)	
10mm LED Clip	6	(UK17T)	
12V Buzzer	1	(FK82D)	
M3 x 10mm Insulated Spacers	1 Pkt	(FS36P)	
M3 x 10mm Steel Bolt	1 Pkt	(JY22Y)	
M3 Steel Nut	1 Pkt	(JD61R)	
M3 Steel Shakeproof Washer	1 Pkt	(BF44X)	
M3 Solder Tag	1 Pkt	(LR64U)	
3A Red Wire	1 Pkt	(FA33L)	
3A Black Wire	1 Pkt	(FA26D)	
PCB	1	(GH57S)	
Top Panel Label	1	(KP65V)	
Back Panel Label	1	(KP66W)	
Instruction Leaflet	1	(XU69A)	
Constructors' Guide	1	(XH79L)	
OPTIONAL (Not in kit)			
8 x AA Battery Box	1	(RK44X)	
PP3 Clip	1	(HF28F)	
Alkaline AA Cell	8	(FK64U)	
2·5mm Power Plug	1	(HH62S)	
300mA Unregulated AC Adapter	1	(XX09K)	

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available as a kit, which offers a saving over buying the parts separately.

Order As LT57M (Live Wire Game Kit) Price £19.99

Please Note: Where 'package' quantities are stated in the Parts List (e.g., packet, strip, reel, etc.), the exact quantity required to build the project will be supplied in the kit.

The following new items (which are included in the kit) are also available separately, but are not shown in the 1994 Maplin Catalogue.

Live Wire Game PCB **Order As GH75S Price £2.99**
Live Wire Game Top Label **Order As KP65V Price £1.99**
Live Wire Game Back Label **Order As KP66W Price £1.28**

WHAT IS PAKNET? – ***Continued from page 13***

accept the most competitive quote from any regional generation company, rather than being tied to the local provider. The local supplier is, however, still responsible for supply and billing. There is clearly a need for accurate and frequent consumption records. Instead of expensive leased lines, the Paknet system can be used to automatically send readings at regular intervals to a central control centre. The next phase of deregulation will allow those who consume 100kW or more to choose their supplier – eventually the right to choose will filter down to smaller businesses and even home users. Remote meter reading has already been hinted at by the electricity industry, even for small users – if Paknet is the chosen system, it will grow at a phenomenal rate.

Other Uses

These applications are the tip of the iceberg. A radio pad linked to a PC (which could be a go-anywhere laptop) can access a wide variety of value-added services. Company databases, financial information, electronic mail and two-way paging systems – indeed, anything on the connected X.25 network. This in itself offers an incredible amount of potential – all that interactive computing power regardless of where you are! A traffic information system based around Paknet has already been featured in *Electronics*. This system, known as Trafficmaster, was reviewed in Issue 47 (November 1991). Started in September 1990 with a M25-orientated service, Trafficmaster has grown to provide coverage of the UK's main motorways. Current users of Trafficmaster are those who would be affected worst by delays – for example fire services, banks, the AA and courier companies. Its acceptance is growing, and what's more, like Paknet itself, it's a British development! Even bookmakers, notably Coral, are using Paknet to provide a more responsive horse-racing betting service. Also on the leisure front, Paknet see the proposed National Lottery as a lucrative opportunity – note that Racal forms part of one of the consortiums bidding to run it.

In the Beginning...

This article has only hinted at some of the vast potential of Paknet. The explosive growth in its coverage since its 1990 inception, aided by its ease of installation, may well help it to become the dominant data communications medium. Even now, a diverse range of applications are currently served by Paknet – ranging from the privatised utilities to retailing. Currently, the number of users totals 14,000, and is currently growing at a rate of 500 new users a month. It will be interesting to see whether the system will introduced into Europe, and possibly on a global basis. In the case of Britain though, whose society is increasingly dependent on up-to-date and reliable information, the future of Paknet can only be described as rosy.

Parallel Pods

High Performance Low Cost PC Instrumentation
Data Acquisition to 20MHz, 32 bit Logic Analyser to 20MHz

Data Acquisition & Softscope

Connecting to the standard printer port of any PC or compatible, the parallel pods offer 100kHz to 20MHz performance from as little as £80.00, including software and interconnecting cable. Up to 4 parallel pods may be connected onto a single printer port. Softscope software is supplied with all units, which is used to setup, trigger and gather data from up to 4 channels, display in X-Y or in Y-T formats and export to most industry standard packages.

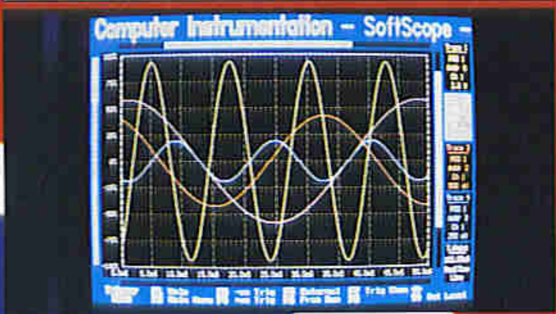
POD 1 — **10uS Single Channel Low Cost**
When used with the Softscope software, turns your PC into a versatile oscilloscope for use in real time or storage mode.

POD 2 — **20uS Dual Channel Simultaneous**
Effectively two POD1 A-D converters packaged together in one enclosure with a single common trigger. Ideal for X-Y Plotting, or as a two channel display.

POD 3 — **1MHz Data Capture with 8k RAM**
With 8kBytes of buffer RAM to POD3 gives true 1MHz operation regardless of the speed of the controlling PC.

POD 4 — **20MHz Data Capture with 8k RAM**
At 50nS per conversion, and with 8kBytes of RAM, high speed events can be easily captured and displayed with the POD4, with the features of an expensive storage scope.

Logic Analyser & IC Tester



In addition to the data acquisition PODS come the Logic Test PODS the POD21 and POD26. Being compatible with the other PODS, they may be used in conjunction. For example using the POD4 with the POD21 provides means of recording both analogue and digital signals together and in synchronism. As with other PODS the POD21 and POD26 come complete with operating software and parallel port cable.

POD 21 — **32Bit Logic Analyser**
Designed to interface with the parallel port of a PC and be used in conjunction with the LogicSoft software, the POD21 provides the functions of an expensive logic analyser at a fraction of the cost. Full 32 bit trigger signatures are provided, with internal or external clocks, running at up to 20MHz. 8k x 32bit words of RAM are provided for data capture with a full featured display.

POD 26 — **Logic I.C. Tester**
The POD26 is an invaluable tool for users of 74 series and 4000 series logic I.C.s. Simply plug an IC into one of the array of Dual in line sockets and the software will quickly identify and test it. Extensive software and component libraries not only identify and test the IC in question, but also provides a display of the truth table. In addition it may be used to analyse the truth table of popular PALs.

Computer Instrumentation Limited

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SEMICONDUCTOR PROCESSING

by Stephen Waddington BEng(Hons)., M.I.E.E.E, A.I.E.E, A.I.T.S.C.

PART THREE From Die to Device

In the two previous parts of this series we have examined how semiconductor materials are grown and looked at the basic processing techniques used to form elements of an integrated circuit. In the final part we make the last step towards the familiar dual-in-line (DIL) and surface mount integrated circuit packages.

The fundamental building block of any integrated circuit is the transistor. There are essentially two reasons for this.

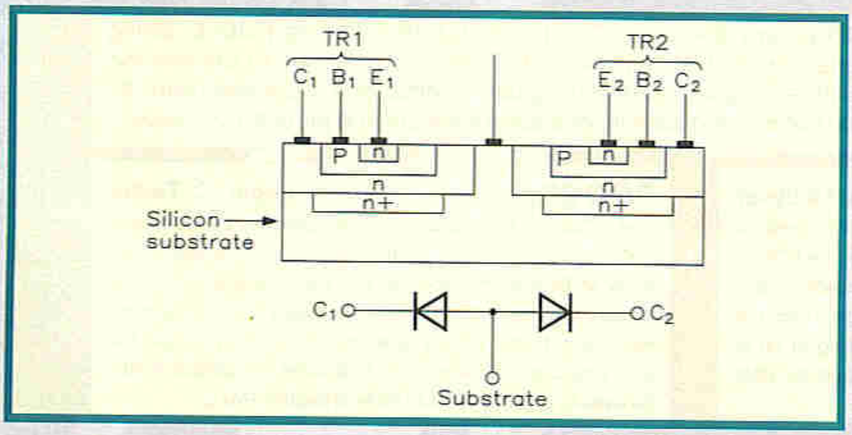
First and perhaps most important, any electronic device that might be used in a discrete circuit such as a resistor, capacitor or diode can be formed, by varying the physical characteristics of an 'npn' transistor. As we shall see later, a 'pn junction' of either the base-collector or the base-emitter can form a diode. A linear region within the 'p-type' base region or 'n-type' emitter region, forms a resistor, and a reverse biased diode may be used as a capacitive element.

Secondly, the transistor structure can be fabricated very easily in monolithic integrated circuits and occupies relatively little space. Consequently unlike discrete circuits, transistors are used liberally in physical integrated circuit designs.

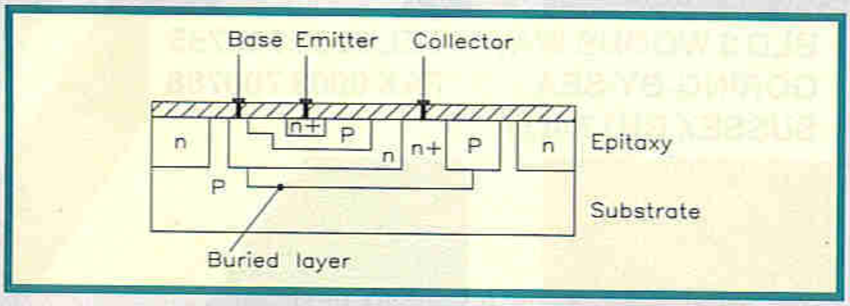
Right: Modern integrated circuits contain up to approximately 15 million pn junctions.

A Problem of Separation

The primary objective of integrated circuit fabrication is to build hundreds of components on to a common semiconductor slice. Forming individual devices is not a problem, but complications arise when several devices are constructed within close proximity to each other. As current fabrication techniques allow approximately 5 million devices to be fabricated on a square centimetre of silicon this can be quite a problem. Care must be taken, to ensure that devices do not overlap and interfere with each other.



Below: Figure 1. Diode isolation between two transistors and electrical representation.



Bottom: Figure 2. Plessey Semiconductor's Process III isolation mechanism.

Numerous fabrication techniques have evolved to overcome this fundamental design problem. Diffusion isolation, or more correctly diode isolation is the commonest form. Here, reverse bias diodes are used to separate the functionality of each device. In Figure 1, two transistors are shown each completely surrounded by p-type silicon. The collector of each transistor forms a diode barrier with the p-region. If the substrate is always connected to the most negative voltage in the system, then irrespective of the voltage on each transistor, the devices would always be separated electrically.

Isolation Mechanisms

The standard diode isolation process suffers from many faults. Leakage currents across the diodes, and parasitic capacitance between the collector and substrate have forced semiconductor manufacturers to develop alternative techniques. These can be broadly grouped into two categories, namely diffusion isolation and oxide isolation.

Plessey Semiconductors have developed a diffusion technique called Process III. This allows high speeds, and is used throughout both analogue and digital devices. It uses a very thin epitaxy and shallow diffusions that give narrow base regions and hence high-frequency response. Process III based on the standard diffusion technique, uses an additional diffusion stage where the collector is taken right down to the substrate layer as shown in Figure 2. This reduces the series resistance of the device, further improving frequency response and reducing voltage drops.

Another form of diffusion isolation, this time from Ferranti Semiconductors, is Collector Diffusion Isolation (CDI). Here the collector surrounds the whole of the device, extending deep into the substrate as shown in Figure 3. Again this is a variant of the basic technique but since the buried layer is close to the base region, the *injection efficiency* of the collector is improved. This means that transistors formed using this technique have a high inverse gain, implying low saturation resistance and high switching speeds. Consequently both digital and linear circuits can be fabricated on the same silicon integrated circuit.

Oxidation isolation techniques are more numerous.

Four common techniques used throughout industry include, Isoplanar from Fairchild Ltd, V-ATE for Raytheon Ltd, VIP from Motorola and Polyplanar from Harris Ltd. All four processes depend on etching the silicon surface to form an oxide isolation barrier.

The Bipolar Transistor

Let us consider how a single npn *bipolar* transistor is constructed on a silicon die. For the sake of simplicity we will initially consider only a single device. The construction of more complex devices and actual integrated circuits such as the TTL range will be considered later.

As we have seen in a monolithic system, the substrate primarily acts as a mechanical holder to the devices, and is usually highly *resistive*. The transistor is formed by a series of up to ten separate implantations or diffusions with each one isolated from the previous by a unique mask.

Fabrication

Initially a thin layer of silicon dioxide is formed on all surfaces of a p-type silicon wafer by exposing it either to oxygen or water vapour in a furnace. The first masking step defines a heavily *doped* n-type (n+) subcollector (or buried layer) which will provide a low resistance connection between the active base-collector area and the collector contact area on the top of the surface. Thermal diffusion or ion implantation is used to form the n+ region as shown in Figure 4a.

After doping, the silicon oxide is removed entirely by chemical etching, exposing the entire surface of the silicon wafer. Next a layer of n-type single crystal silicon is grown epitaxially by a chemical vapour deposition (CVD) process at high temperature. During this process, the n-type dopant in the buried layer diffuses in all directions, including upwards into the new epitaxial layer as illustrated in Figure 4b.

A new layer of silicon oxide is now grown to form a collector region. A second masking step defines a border completely enclosing the isolated n-type regions as shown in Figure 4c. A p-type diffusion is continued until the entire epitaxial layer has been penetrated. This forms the basis of the isolation mechanism that will prevent the transistor from adversely affecting the functionality of others within close proximity.

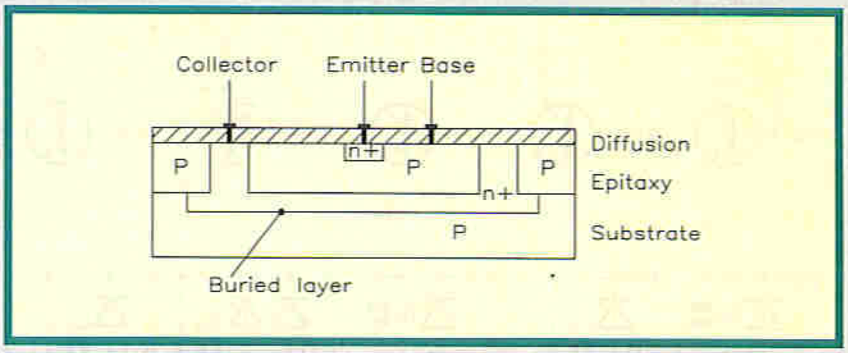
Again the silicon dioxide is removed and a new layer formed over the isolation layers. The third masking step defines the base region. A dopant such as boron (B) (from group 3 of the periodic table) is used to form the p-type base as shown in Figure 4d. The n-type material is converted to p-type when the density of p-type dopants exceeds that of the n-type impurities. This is called overcompensation.

The fourth masking step defines the n-type transistor emitters and the n-type regions for low resistance contacts to the collector regions as shown in Figure 4e. Again, conversion of the p-type base to n-type requires overcompensation, so each succeeding diffused or implanted layer must be increasingly heavily doped than the one it must compensate.

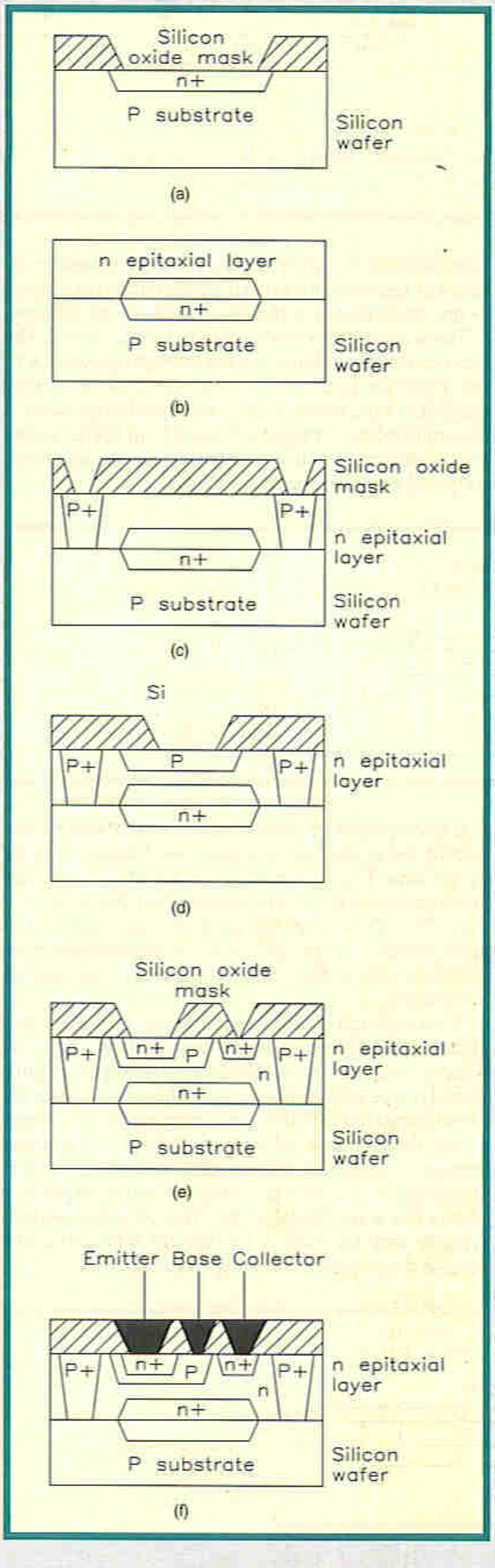
The fifth masking step defines contact areas to collector, base and emitter. A thin layer of aluminium (Al) is evaporated over the entire surface and then etched in a pattern defined by a sixth mask to form the desired interconnections as shown in Figure 4f. A protective passivating layer is deposited over the entire surface followed by a final masking step which removes this layer over the pads where contacts will be made.

Other Components – Diodes

Having considered the transistor, how are other components formed? In the case of diodes, there are a number of possibilities depending on the electrical characteristics required. It is not usual to fabricate exclusively a pn junction when two regions of a transistor can be utilised more easily. Clearly there are a number of



Above: Figure 3. Ferranti Semiconductor's Collector Diffusion Isolation (CDI) isolation mechanism.



Left: Figure 4. Basic stages in npn bipolar transistor fabrication:
(a), n+ subcollector or buried layer;
(b), Epitaxial layer;
(c), n-type isolation enclosure;
(d), p-type base;
(e), n-type transmitter and n-type regions;
(f), Contacts.

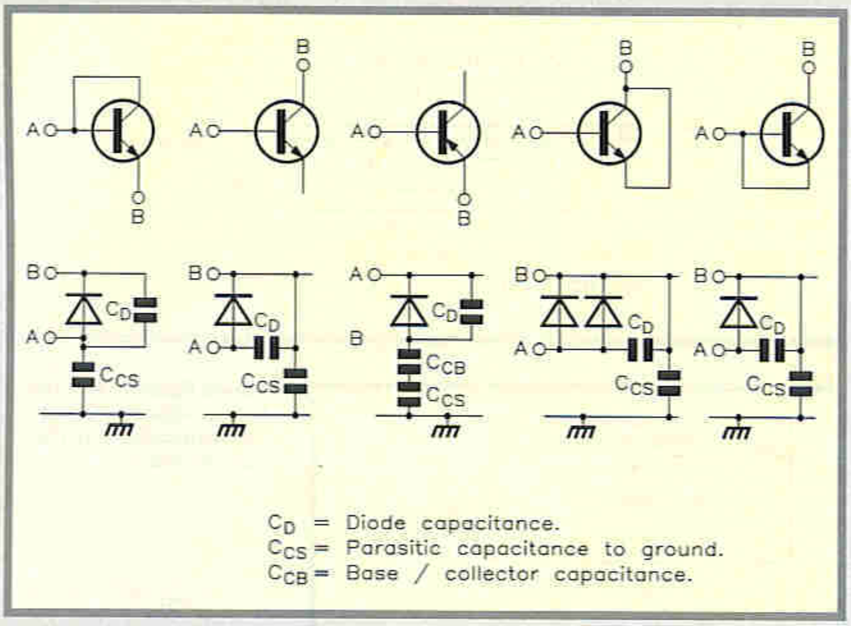
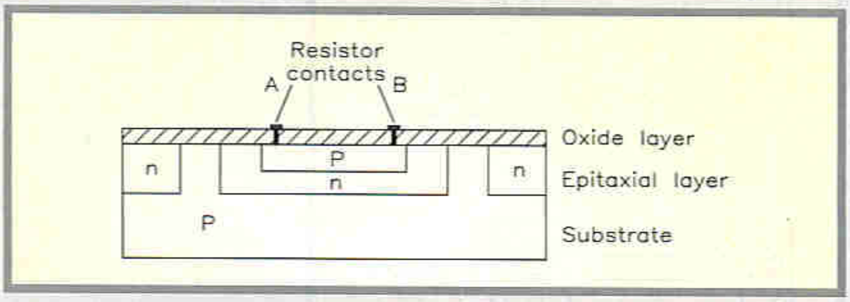


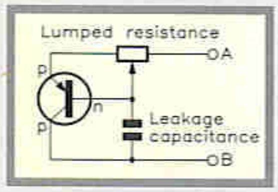
Figure 5. Monolithic diodes formed from bipolar transistors and equivalent electronic circuits.

possibilities as shown in Figure 5. The characteristic differences between the various configurations is primarily due to variations in the distance of charge diffusion.

There are other critical factors to be considered. The capacitance of the diode and the leakage capacitance to the substrate both dramatically effect the frequency capability of the diode. In this sense, the fastest diode is the emitter-base arrangement since both these regions are heavily doped with impurities, implying a low resistivity and negligible capacitive effect.

Below: Figure 6a. Monolithic base diffused resistor.



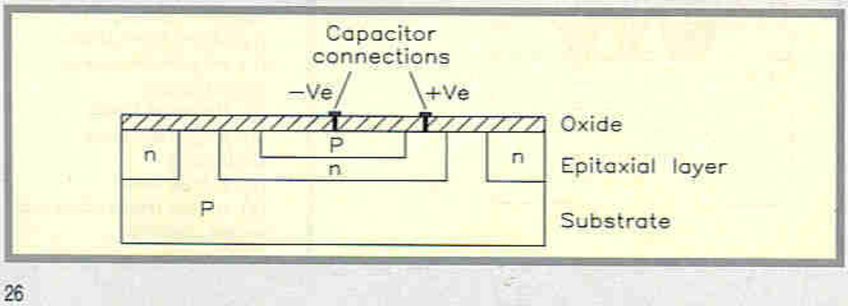


Above: Figure 6b. Equivalent electrical circuit.

It is also possible to obtain Zener diode action by connecting the emitter and collector, and biasing it positive to the base. This is something you could try with a discrete transistor, but do not except a high degree of accuracy. The Zener voltage using this arrangement is approximately 7V, though this will vary appreciably from device to device depending on manufacturing process parameters.

A second type of diode used frequently in integrated circuits is the Schottky device. Essentially it consists of a metal area such as aluminium overlaid upon a lightly doped n-type region. The excess of free electrons in the metal compared with the more restricted n-type region causes the formation of a barrier voltage (or Schottky voltage) at the junction. If the metal is biased positive to the n-region it conducts current, if biased negative it blocks like a traditional diode. The Schottky diode is typically very fast with a 1ns storage time and a low voltage drop when conducting – typically 0·3V.

Below: Figure 7. Monolithic diffused capacitor.



Resistors

The characteristics of a diffused semiconductor strip are used to form resistors. For high resistance values, the resistivity must be as high as possible. However, this requires a low impurity doping, reducing the temperature coefficient of the semiconductor. Physical dimensions are also limited. A resistor can only occupy a small amount of an integrated circuit, otherwise there will be little space available for other components. Generally, resistivities of 300Ω can be tolerated without adversely affecting the temperature coefficient.

The absolute accuracy of a diffused resistor is limited to approximately 10%, due primarily to the difficulty of controlling the diffusion process between individual dies and the tolerance of mask dimensions. Within an integrated circuit the relative tolerance is 3%, dependent on tolerance's in diffusion, masking and etching.

There are other possibilities. The base resistance of the base region of a transistor is typically 200Ω and is frequently used. The resistivity of both the emitter and collector regions are too low and too high respectively to be useful. Figure 6a shows a diffused resistor in the base region of a transistor. This can be fabricated at the same time as other transistor devices using similar masking techniques. A circuit diagram of the arrangement is shown in Figure 6b.

Capacitors

Monolithic capacitors are not frequently used in integrated circuits as they are limited in range and performance. There are however, essentially two types; diffused capacitors or metal oxide silicon (MOS) capacitors. The diffused capacitor relies on the reverse bias characteristics of a diffused pn junction. Using the transistor model, this can either be the collector-base or emitter-base junction as shown in Figure 7. In this case capacitance is proportional to the area of the junction and inversely proportional to the *depletion thickness*. Both parameters are in turn dependent on the resistivity of the junction materials. Therefore desirable characteristics for large value capacitors are, a thin depletion region, large junction area, and high impurity concentration.

Diffused capacitors have a very poor voltage coefficient since the depletion thickness is dependant on the bias voltage. Typical values are 1·2nFmm^{-2} using a base resistivity of 200Ω, which decreases dramatically for larger bias voltages. Low values of Q, (the ratio of reactance to resistance) which implies poor frequency response, is also due to the large resistivities involved in fabricating diffused capacitors.

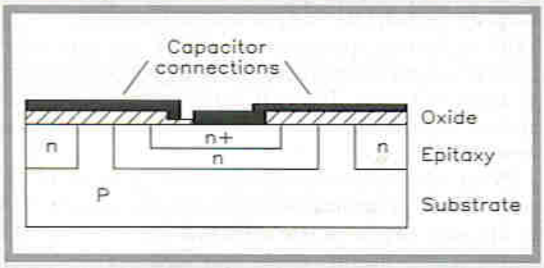
A MOS capacitor uses a thin layer of silicon oxide as a dielectric as shown in Figure 8. One plate is formed from a metal layer, while the other from a heavily doped layer of silicon. The capacitor has a lower leakage current than its diffused counterpart, and a much larger Q due to lower material resistivities. The capacitance value can be varied between 300 and 800pFmm^{-2} and is independent of both applied voltage and polarity.

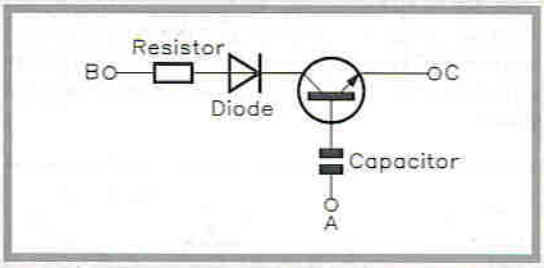
The major disadvantage of this type of capacitor lies in the fabrication process. Additional processing stages are required to form the oxide layer and metal interconnections, increasing the production complexity. Generally all monolithic capacitors are inferior to discrete devices, and unless there are obvious benefits to be had by fabricating semiconductor devices, designers will opt for the discrete device.

An Integrated Circuit

Having considered the fabrication of transistors, diodes, resistors and capacitors, let us now look at how each of these might be combined to form a simple integrated circuit. Figure 9 shows an electronic circuit that forms the basis of numerous commercial 3-pin integrated circuit packages. How is this device fabricated?

The starting material is a slice of highly polished silicon of up to 12in. diameter as shown in Figure 10a. The





Far Left: Figure 8. Metal oxide silicon capacitor.

Left: Figure 9. Electronic equivalent circuit of a typical three pin integrated circuit.

slice will be capable of accommodating many thousands of similar integrated circuits which would all be fabricated in a single process.

Transistor First

The first step is to diffuse the transistor buried layer which will provide a low resistance contact in the base-collector area of the transistor, and prevent Schottky action as shown in Figure 10b. This is achieved as we have seen previously, by growing a silicon dioxide layer on the surface of the wafer, and by photographic techniques, such as etching a window in the required position. Next, an n-type dopant is heavily diffused into the region as shown in Figure 10c. For initial layers such as this, arsenic (As) is often used, since it diffuses slowly and will not move during subsequent fabrication stages.

An n-type epitaxial layer is grown over the whole area as shown in Figure 10d, followed by a silicon oxide layer. Again photolithography is used to define windows through which isolated regions can be diffused, as shown in Figure 10e. This forms the basic isolation mechanism between each of the four devices. A silicon oxide layer is grown over the surface and masked to form the p-diffusion region of the transistor base and other regions as shown in Figure 10f. The doping concentration is selected to suit the transistor requirement, not the capacitors, resistors and diodes, and this limitation must be accepted.

A fourth photographic mask is used to form the emitter regions of the transistor as shown in Figure 10g, followed by a fifth mask that opens up the contact areas of the silicon surface. Finally, a metal layer (usually aluminium (Al)) is deposited over the device and etched to form the interconnection pattern shown in Figure 10h.

After six masking stages it is apparent that the fabrication of even this very basic integrated circuit involves a great deal of processing between photolithographic, epitaxial, oxidation and diffusion plants. Careful handling is required at all stages, and each operation should be executed in a clean atmosphere since impurities will damage the silicon wafer and act as undesirable dopants.

A different furnace is required for each dopant, since equipment quickly becomes saturated by the dopant chemical. This means a bank of at least eight diffusion furnaces are required for a single process. It quickly becomes obvious, that establishing a fabrication process even for the simplest integrated circuit is an expensive business.

Unipolar Devices

Manufacturers of unipolar integrated circuits incorporating field effect transistors use the same fabrication techniques employed for bipolar devices. The two essential physical differences are that the epitaxial layer is replaced by a thin gate oxide, and the isolation mechanism is formed using heavily doped barrier regions.

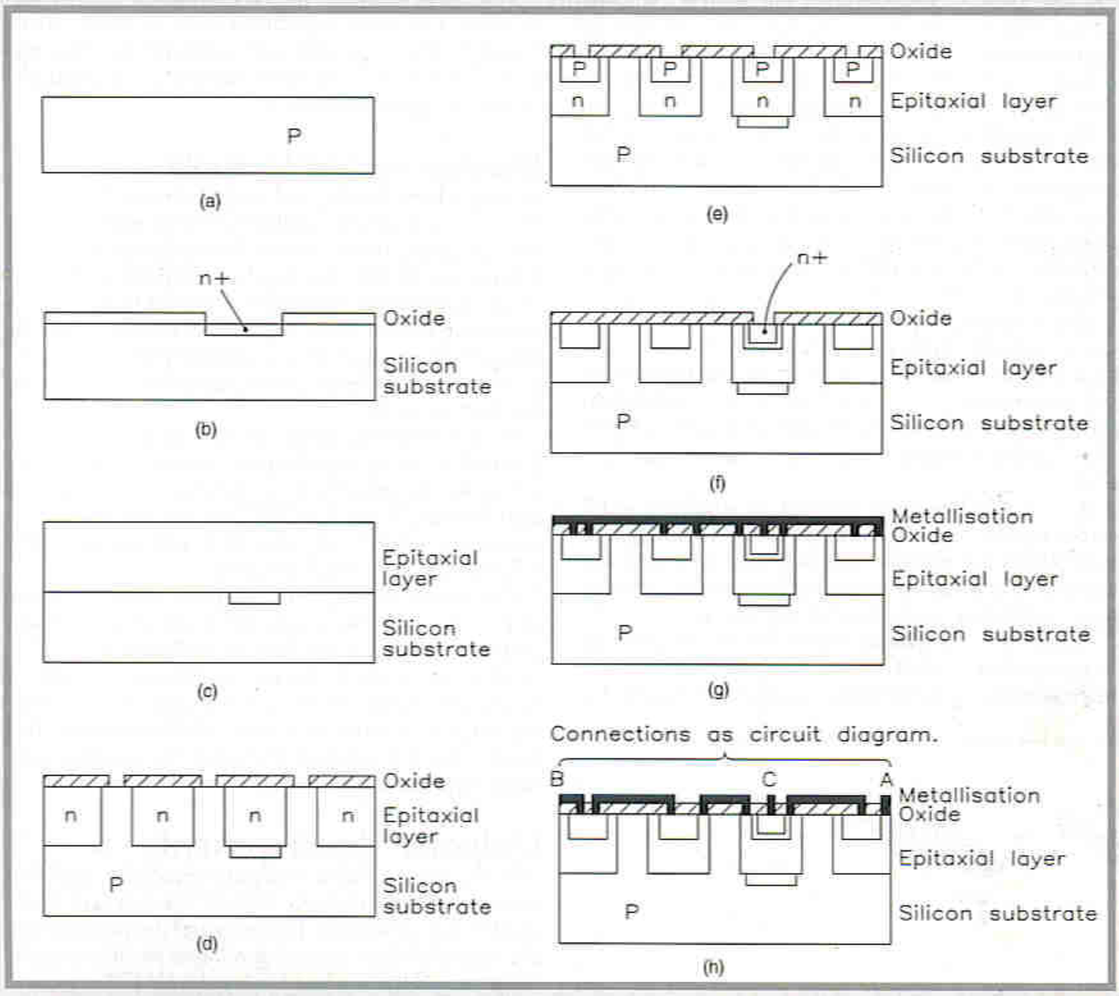


Figure 10. Stages in the fabrication of an integrated circuit:
(a), Silicon die;
(b), Buried layer diffusion;
(c), Epitaxy;
(d), Isolated diffusion;
(e), Base diffusion;
(f), Emitter diffusion;
(g), Metal deposition;
(h), Interconnection etch.

Let us consider how an NMOS (n-type conducting channel) unipolar transistor is fabricated. Complementary MOS (more commonly CMOS) combines both n-channel and p-channel devices in a single integrated circuit.

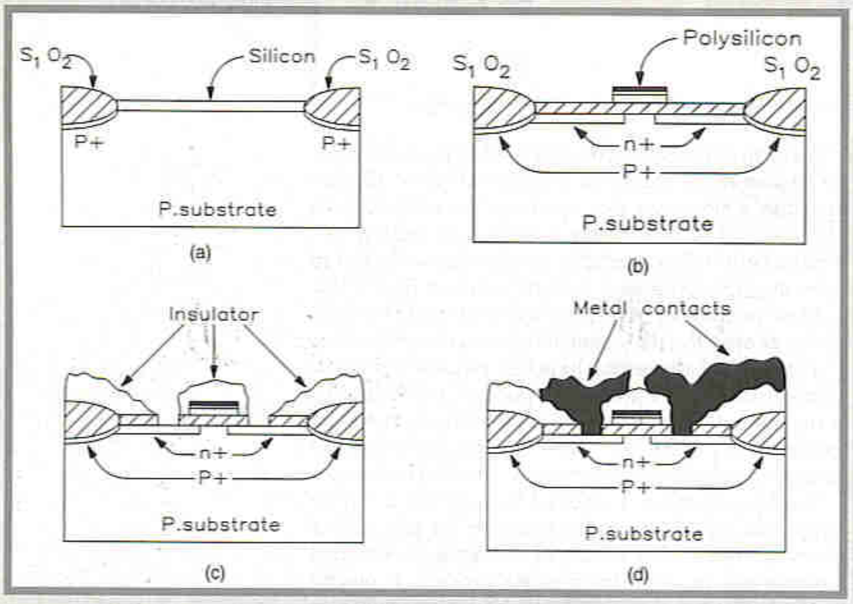


Figure 11. Basic stages in the fabrication of an n-channel MOS device: (a), Transistor definition and isolation mechanism; (b), Silicon oxide and polysilicon; (c), Insulating layer; (d), Metal deposition.

NMOS Fabrication

Figure 11a shows a p-type segment of a silicon wafer. A thin layer of silicon nitrate (Si_3N_4) is deposited by CVD on the entire wafer surface. The first masking step defines areas where the transistors are to be formed and the Si_3N_4 is removed from outside the transistor areas by chemical etching. Boron (B) (p-type) is implanted in the exposed region, followed by a layer of silicon oxide (SiO_2) to form the isolation mechanism. In this case the Si_3N_4 inhibits the growth of oxide in the transistor regions. With its function over, the Si_3N_4 is removed using an etchant that does not attack SiO_2. A layer of approximately one micron thick SiO_2 is grown in the transistor areas. This is a critical stage in the process, since it forms the gate oxide which must be thin to give a low operating threshold, but also pure to maintain device stability. It must also be free from pinholes that would short the metal electrode to the silicon surface. A second CVD process deposits a layer of polycrystalline silicon over the entire die in preparation for a second masking step that defines the required patterns for the gate electrodes.

Undesired polycrystalline silicon is removed by chemical or reactive ion etching. An n-type dopant (phosphorus (P) or arsenic (As) is introduced into regions that will become the source and drain by ion implantation through the thin silicon oxide layer as shown in Figure 11b – giving automatic alignment of source, gate and drain.

A third CVD process deposits an insulating wafer across the whole wafer, accompanied by a masking step that defines the areas in which contacts to transistors are to be made. Chemical etching bares the silicon layer in the contact areas as shown in Figure 11c.

Aluminium is evaporated over the entire wafer to form contacts while a final masking step defines the required interconnection pattern as shown in Figure 11d.

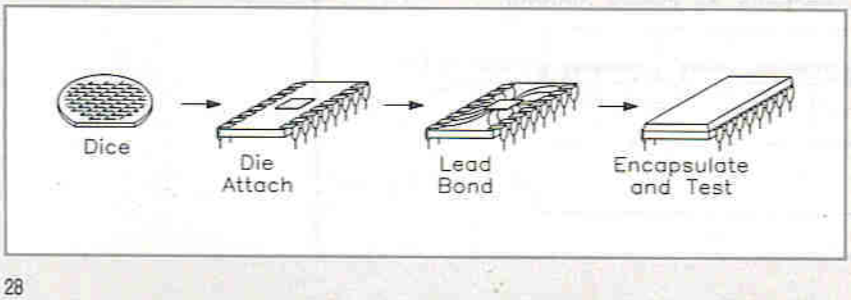


Figure 12. Final stages of integrated circuit fabrication.

Operational Characteristics

With no voltage applied to the device, the path from drain to source is obstructed by two pn junctions back to back in series. There is no conducting channel present and the only current that flows is due to diode reverse leakage.

When source, drain and body are all grounded and a positive voltage applied to the gate, the high electric field in the gate region draws electrons into the channel region under the thin oxide layer. The heavily doped n-type source and drain regions provide a copious source of electrons.

A minimum threshold (V_T) of gate source voltage (V_{GS}) is required to form a channel of the order 0·5V to 2·0V. With a conducting path now present, current flows between drain and source – the size of current flow is dependent on the gate voltage since the conductivity channel is dependent on the gate voltage.

New DMOS Plant

Texas Instruments has unveiled plans for a new plant in Dallas that will give the company one of the world's largest semiconductor wafer fabrication facilities. Investment in the new plant will be undertaken in phases starting in 1998 and is expected to total between US$750 million and US$1 billion.

The new facility will be called DMOS 5 and will be attached to Texas Instrument's existing DMOS 4 facility, which was built in 1984 and expanded in 1988. Combined, DMOS 4 and DMOS 5 will give Texas Instruments one of the world's largest semiconductor complexes under one roof. With a total of more than 90,000 square metres of space, it will include 13,000 squares metres of top class clean room area.

DMOS 5 will produce semiconductors with dimensions as small as 250nm, or 400 times smaller than the diameter of a human hair. Eventually, the facility will produce semiconductors as small as 120nm, or more than 800 times smaller than the diameter of a human hair.

The entire complex will rank as one of the world's cleanest and most environmentally sensitive areas. Systems inside the plant will automatically clean the exhaust fumes, recycle water, reprocess chemicals and reduce energy consumption.

Bipolar versus Unipolar

Although both bipolar and unipolar transistors derive their names from the number of charge types involved in their action, there are two fundamental operational differences. Firstly the bipolar transistor operation occurs at the base region which is buried some distance below the surface within the bulk of the silicon die. By comparison, conduction in a unipolar transistor occurs due to the formation of a conducting channel under the thin surface oxide.

For this reason a unipolar device is susceptible to contamination during manufacture and spurious voltages during its operating life time. Perhaps it now becomes clear why data sheets for CMOS devices describe extensive static handling and operating precautions, while TTL technology is more forgiving.

The second operational difference between bipolar and unipolar devices is apparent from an examination of their respective cross-sections in Figures 4f and 11d. In a bipolar transistor, the base metal connects directly to the embedded silicon, and the gate of a unipolar transistor is isolated by a layer of silicon oxide. This means that the unipolar transistor has a higher gate input impedance.

Unipolar Developments

Whereas the main battle in bipolar technology has been to increased circuit density, unipolar systems have developed in two directions. Ten years ago the prime objective was to reduce operating voltages so that unipolar circuits could be interfaced to bipolar 5V TTL logic, and more recently 3V rails. With this objective achieved, attention has been focused on making unipolar circuits faster.

Packaging

Once an integrated circuit has been fabricated (whether it be bipolar or unipolar) and interconnecting layers added to ensure individual circuits are linked as required, the device must be packaged so that it may be used as part of a discrete circuit.

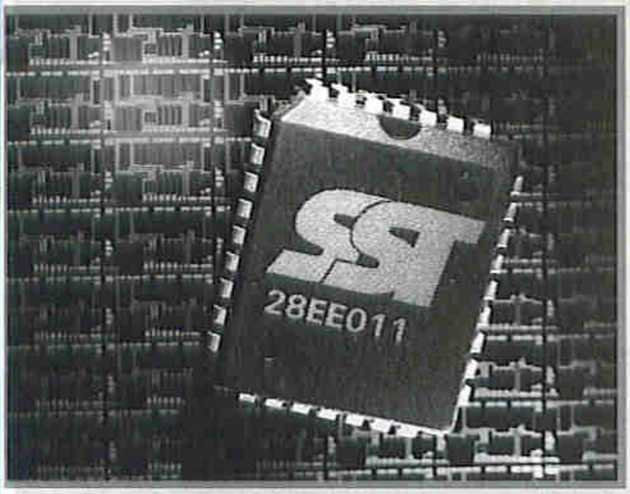
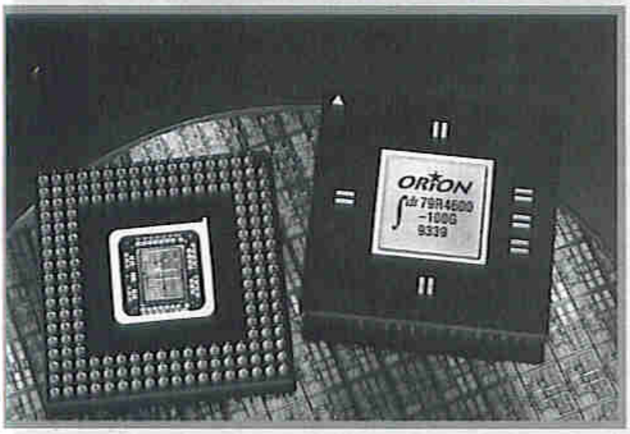


Figure 12 illustrates the final stages in the manufacturing process. Individual dies are tested on the wafer, before being separated and bonded to a thick film substrate. The bond may be made to a main conducting track (if the substrate itself is a conducting element) or more usually to an insulating section of the die. It must therefore have either good electrical conduction or insulation properties as well as having mechanical strength, good heat conduction and should not create any undesirable pn junction.

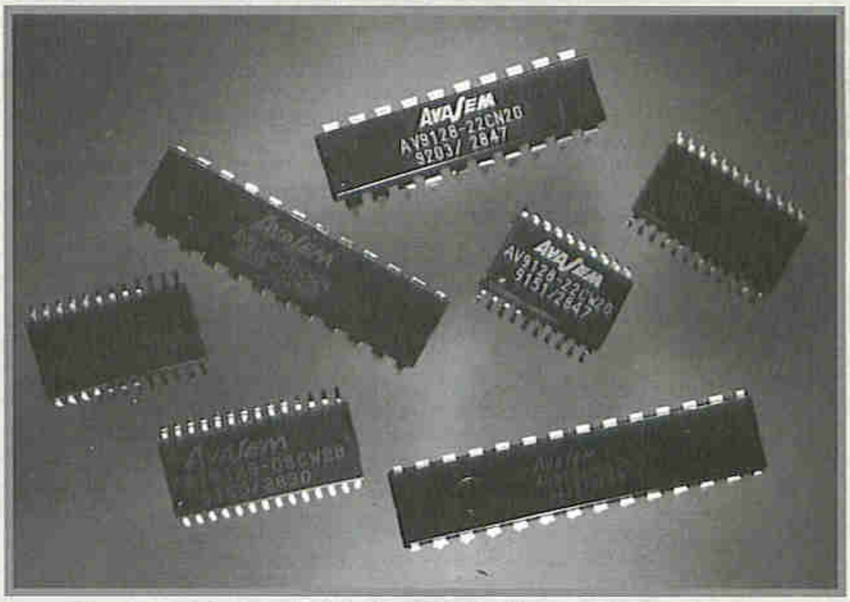
Having fixed the silicon die to a substrate, wire bonding techniques are used to connect electrically the metallised pads to either conducting tracks within the case or to package leads. Thin gold or aluminium wire is used for this task and connections made by thermo-compression or ultrasonic bonding methods.



The Dual-In-Line Package

Integrated circuit packaging could quite easily occupy an article within its own right, but we will limit ourselves here to the most familiar plastic and ceramic arrangements.

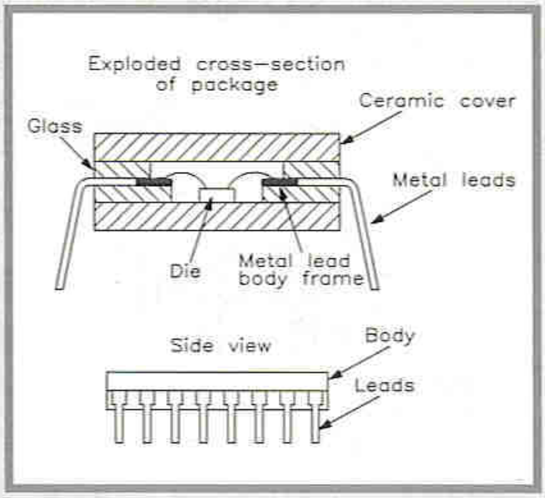
The most commonly used plastics are epoxy and silicone resins. Both materials are used because of their excellent adhesive and thermal properties. Good adhesion to the die is essential so that damp ingress is prevented, while a high thermal expansion coefficient prevents stresses forming in the package that could damage the leads or fine bonding wires.



Resin Shortage

Last July, an earthquake in Japan, caused a fire at the Sumitomo Chemicals plant – previously the world's main supplier of epoxy resin used to manufacture semiconductor devices. The effect on the semiconductor industry has been devastating, causing panic buying of integrated circuits.

One result is the escalation in the price of single in-line memory modules (SIMMs) – the RAM integrated circuits mounted on tiny PCBs, used to extend PC memory. Whereas 1Mb SIMMs previously cost between £20 and £30 last summer, they are now selling for about £40 each.



The ceramic dual-in-line package as shown in Figure 13 will probably be a familiar integrated circuit to readers. In this case the die is housed in a cavity and bonded by an insulating glass composition. The ceramic lid is initially metallised and then sealed onto the body using a soft solder technique.

Plastic dual-in-line packages do not have a cavity for the die. Instead the moulded package completely surrounds the package.

Packages used to house VLSI devices can present a problem. These integrated circuits are relatively large and generally have many outputs – typically 40 to 60. Although dual-in-line packages are still used, several superior arrangements based on surface mount technology have evolved. Apart from having a footprint area which is about a third of through-hole mounted components, surface mounted packages are often the only economical way of handling devices with pin-outs greater than about 40. Pin grid arrays can be used, but are more expensive.

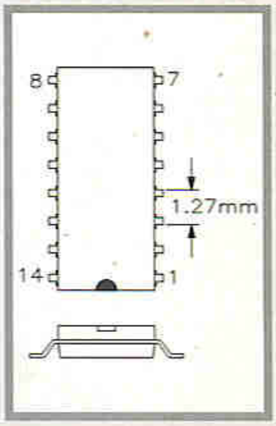
Above: SOIC packages shown alongside DIL integrated circuits.

Far Left: An individual die may be copied across a silicon wafer, enabling numerous integrated circuits to be fabricated simultaneously.

Below Far Left: Grid array packages are relatively expensive compared with other packages.

Left: Figure 13. Exploded cross section of ceramic dual-in-line integrated circuit package and side elevation.

Below: Figure 14. SOIC package with winged leads.



GLOSSARY

Bipolar transistor: An electronic device in which both electrons and holes play an essential role in its operation. In common usage a bipolar junction transistor is usually referred to simply as a transistor.

Depletion layer: A region within a semiconductor device that has a net charge due to insufficient mobile charge carriers. Depletion layers are inevitably formed at the interface between two dissimilar conductivity types of semiconductor (pn junction), in the absence of an applied voltage and at the interface of a metal and a semiconductor (Schottky barrier).

Doped: The application of a particular type of impurity to a semiconductor in order to achieve a desirable level of n-type or p-type conductivity. Donor impurities are added to form an n-type semiconductor and acceptor impurities for p-type.

Electrons: A stable elementary particle that has a negative charge of $1{\cdot}602 \times 10^{-19}$ coulomb, mass m of $9{\cdot}109 \times 10^{-31}$kg. Electrons are constituents of all atoms, moving around the nucleus in several possible allowed orbits. They may also exist independently.

Injection efficiency: The efficiency of a pn junction under forward bias, defined as the ratio of the current carried by injected minority carriers to the total current across the junction.

n-type: Conduction in a semiconductor in which current flow is caused by the movement of electrons through the semiconductor.

ñ+ doping: Heavily doped n-type semiconductor.

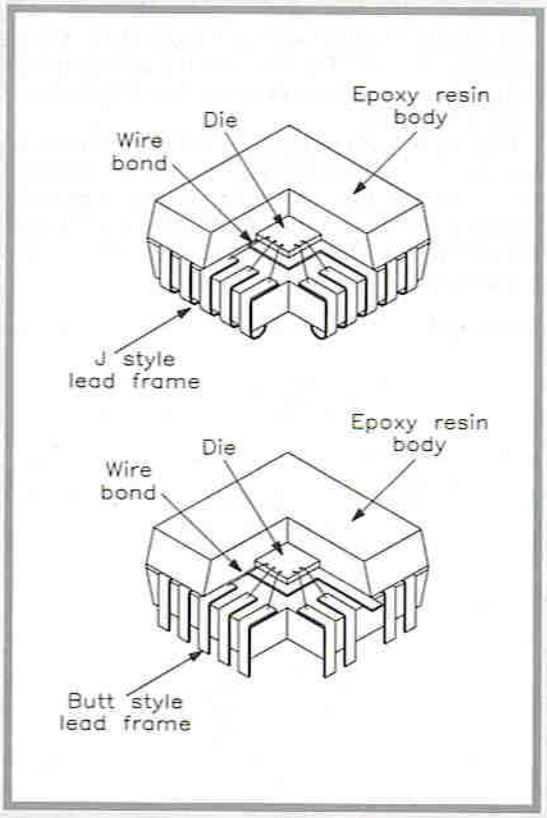
p-type: Conduction in a semiconductor in which current flow is caused by the movement of electrons through the semiconductor.

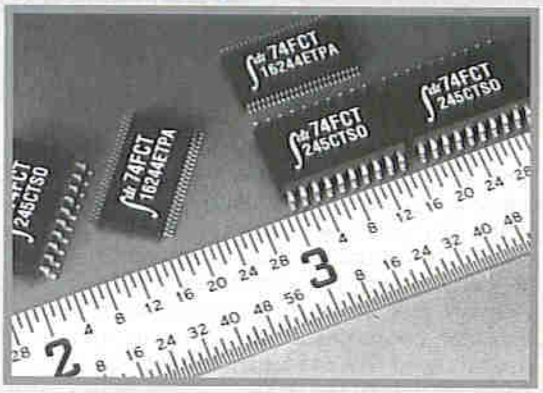
p+ doping: Heavily doped p-type semiconductor.

pn junction: The region at which two semiconductors of opposite polarity meet. A simple pn junction (a homojunction) is formed of the same material in which doping levels lead to two different conductivity types.

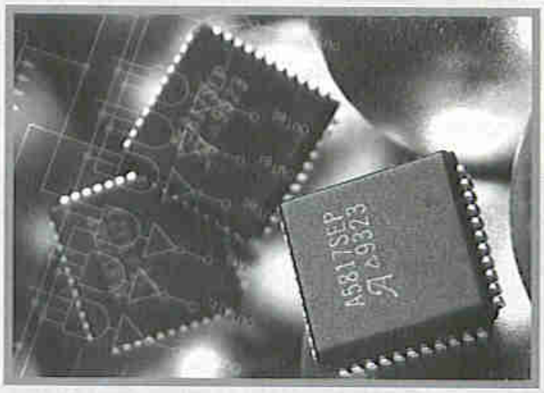
Resistivity: A material property equal to the resistance per unit length. Resistivity is the reciprocal of conductivity; the lower the resistivity of a material, the better conductor. In semiconductors, the higher the doping level, the lower the resistivity.

Right: Figure 15. PLCC packages with both J-style and butt leads





Top Far Right: Packages like the small outline integrated circuit (SOIC) save approximately 60% space over conventional dual in line devices.



Bottom Far Right: PLCC have an even greater pin density than all other forms as pins are placed on all four sides of the device.

SOIC and PLCC

Figure 14 shows the small outline integrated circuit (SOIC) with winged leads that extend out from the two sides of the package at intervals of 1·27mm. The package is thin and therefore requires very little board width. The solder pads are also small leaving room for tracks to be run between pads when laid out on a printed circuit board. The package is self-aligning with the viscosity of the solder causing the leads to be pulled into place on its pads, and because solder joints are visible, they can be easily inspected.

Placing pins on all four sides of the integrated circuit package further increases the number of pin outs. Plastic leaded chip carriers (PLCC) can have either winged or J-shaped leads as shown in Figure 15. The package is again self-aligning, but since the solder joints are made under the package they cannot be readily inspected. An alternative non surface-mounting arrangement uses a holder to enable the PLCC style package to be used on conventional printed circuit boards.

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Sincere thanks are due to Dr. G. Farrell of the University of Salford who taught the author almost all he knows about the subject of Integrated Circuit Fabrication & Design.

Further Reading

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The Design and Analysis of VLSI Circuits, L. A. Glasser & D. W. Dobberpuhl, Addison-Wesley.

NEXT issue

There are more terrific projects and features winging your way in next month's super issue of *Electronics – The Maplin Magazine*, including:

PROJECTS

INTELLIGENT Ni-Cd BATTERY CHARGER

This project uses an IC specifically designed to handle the needs of Ni-Cd batteries, and its use can improve the performance of cells with 'reduced capacity', through a constant current discharge and charge cycle. Switches allow different voltages and capacities to be catered for, thus preventing overcharging. Sophisticated monitoring of both voltage and temperature allow reduced capacity ('damaged') batteries to be charged, using a pulsed output technique.

REUSABLE FUSE

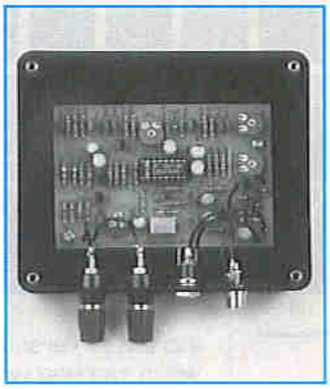
Self-resetting electronic fuses, which behave rather like conventional slow-blow fuses and can replace them in many applications, have a significant advantage over the traditional type, especially for experimental work and initial trials on newly constructed circuits. This project uses a MFR020 fuse suitable for currents up to 200mA. The Reusable Fuse is an intelligent system which is fitted between any test circuit and its power supply, in the range +4 to +18V DC. If the current exceeds 200mA for any reason, a buzzer gives a short bleep and an LED flashes continuously; the current then falls to a very low holding value until the fault has been corrected.

CAR ALARM ULTRASONIC INTERFACE

Current trends in vehicle crime involve smash and grab offences, with forced entry through parts of a vehicle not protected by current sensing equipment. This project provides the facility to interface an ultrasonic sensor to an alarm system; adding further protection to basic current sensing-only car alarm units. Standard 3-wire ultrasonic sensors, such as those by Moss are ideal for use with this interface.

MODEL TRAIN CHUFFER

One aspect that is normally missing from a model train set is the actual sound of a chuffing train. This model steam train chuffer produces a realistic chuff whilst the train is in motion, and a hissing sound emulates escaping steam, whilst the train is at standstill. A power supply of approximately +20V DC is required. Adjustment of the 'chuff' rate can be made to match the train speed, and the tonal balance can also be adjusted to suit. Once in operation it lends realism to any model steam train set.



FEATURES

A new three-part series begins next month all about the history and workings of 'Surround Sound', covering variations from two-channel stereo to the latest developments. Other features continue with the final instalments of How to Use Digital Panel Meters, and Transmission Lines.

Special features describe how to choose and use Video Connectors, and how video images will soon be handled via computer networks. All this plus all your favourite regulars too!

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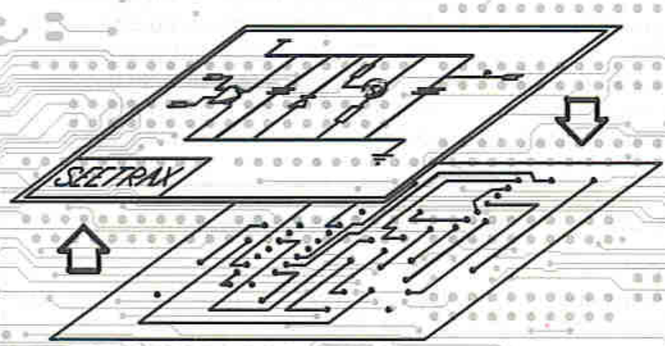

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LET'S GET DIGITAL with the TTL Test Unit

by Terry Pinnell

I expect those people who have taken up electronics fairly recently are much more at home with digital circuitry than I was in the early stages of this hobby. Some are probably even using microprocessor chips in their projects with a lot more confidence. But if you are not yet at that advanced stage, and if CMOS has not completely banished TTL (Transistor-Transistor-Logic) from your component drawers, then I'd warmly recommend that you consider making your own version of this project. Quite apart from its usefulness on the workbench, it provides both educational and practical value.

The 'TTL Test Unit' consists of up to nine separate circuits in the one case, all powered from an external 5V supply. Apart from testing existing logic systems, its other useful role is as an aid to developing experimental logic circuits to explore TTL digital logic, and it has proved extremely useful for that purpose.

Summary of Circuits

The nine circuit modules are summarised in Table 1 (right), each is described in detail later.

Note that for some of them, specifically the noise-free switches, logic level testers and inverters, the individual circuits are duplicated for increased versatility. Quite often, when working with TTL circuits, you will need to supply several logic inputs or monitor several outputs. You could of course decide to incorporate only a subset of the nine modules, thus altering the nature of the finished instrument. For example, without the logic testing sections it essentially becomes a TTL signal generator, or conversely if you include only the output monitoring parts then it could simply be called a TTL logic tester. And of course any one of the modules could be constructed for a specific purpose, to be used on its own.

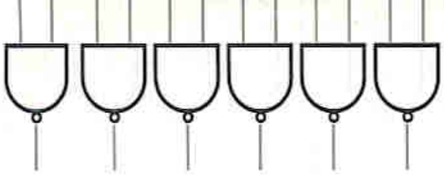
Module 1: Noise-Free Toggle Switches

As soon as you start working with digital circuits of any kind, you will quickly find that you need manual test signals which make a clean transition from Low to High and vice versa, once and once only each time the switch is operated. If you try using an ordinary on/off switch, there will be multiple transitions because the mechanical contacts bounce.

This is a well-known problem with digital circuitry, and has given rise to 'debounced' input stages and debouncing algorithms in microprocessor software and some specialised ICs. There can be dozens of such spurious signals with some cheap toggle or slide switches. This was brought home to me dramatically when, in my naivety, I first tried connecting such a switch to a TTL counter I had proudly constructed. Each time I toggled the switch from High to Low to clock the counter chip, the two-digit

Module Description	No. off	IC(s) Device Type
Signal Generators:		
1. Noise-free toggle switches	3	IC1a,b,c,d & IC2a,b = 1½ x 74LS00
2. One-Shot Pulse Generator	1	IC1 = 74121
3. Push to Change button	1	IC1c,d = ½ x 74LS00 (IC2 above)
4. Clock: 1/30Hz to 240kHz	1	IC1 = 555, IC2a,b = ½ x 74LS00
5. Inverters	2	IC1c,d = ½ x 74LS00 (IC2 above)
Logic Level Testers:		
6. #1 High, Low & Pulses	1	IC1 = 74121, IC2a = ¼ x 74LS00
7. #2 High, Low & Intermediate	1	IC1a,b,c = ¾ x 3900
8. #3 Simple High/Low	1	IC1d = ¼ x 3900 (IC1 above)
9. Negative Pulse Indicator	1	IC1c,d = ½ x 74LS00 above

Table 1. Summary of the nine modules included in the TTL Test Unit.



7-segment display at its output jumped to some arbitrary number, such as from 5 to 46, or 73 to 21. *I wasted a lot of time looking for something that was wrong with my counter rather than my input signal.* With a proper switch, like those presented here, your logic circuitry will only get *exactly* the number of pulses you want to give it.

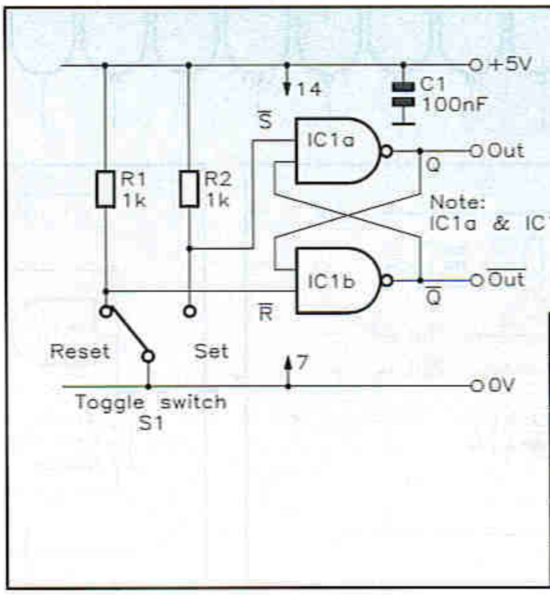
The complete TTL tester has three identical modules, the detailed circuit diagram for one only is shown in Figure 1. The three modules or circuits all share two quad 2-input NAND gate ICs, and the actual gates used in these ICs are summarised in Table 2. The three switches use a total of one and a half chips, leaving half remaining for further use in one of the other modules. The TTL chip chosen is the 74LS00 low-power Schottky type, as these are now considerably cheaper than the foregoing 7400 yet with superior specification. The pin-outs are shown in Figure 2, together with the internal schematic of the gates, as an aid to wiring up the circuits using this chip.

The Noise-Free Switch circuit is a basic bistable, alternatively called a Set-Reset or S-R flip-flop. The bistable crops up time and again (in CMOS as well as TTL), so it's worthwhile fully understanding how it works.

Suppose, to begin with, that the toggle switch is in the Reset position. This means that $\overline{R}$ is low and $\overline{S}$ is high. The truth table shows that in these circumstances the output Q is low (Q = 0). If the switch is now moved towards the Set position, $\overline{R}$ goes high, as the contacts come apart, albeit perhaps only for a few milliseconds, due to the inevitable noise. Meanwhile the $\overline{S}$ input on pin 1 is still high, because contact has not yet been made on that side of the switch (assuming it is not one of the make-before-break types.)

So, during this brief changeover period, both inputs are high, which the truth table shows results in *no-change;* the output remains high. But as soon as the sprung switch's contact reaches the other side, it takes $\overline{S}$ low and so the Q output goes high, because $\overline{R}$ = 1 and $\overline{S}$ = 0. But $\overline{R}$ is now steadily high, so even if the switch contact bounces off the Set position again, briefly making $\overline{S}$ = 1, the truth table shows that there is *no-change* in the low output.

Therefore, throughout the short transition the Q output remains low,



Truth Table

$\overline{R}$	$\overline{S}$	Q	$\overline{Q}$
0	0	Not allowed	
0	1	0	1
1	0	1	0
1	1	Stays the same	

Figure 1. Circuit and truth table of the Noise-Free Switch module (1 of 3).

Switch	IC	Pins	Resistors
1	1a & 1b	1, 2, 3 & 4, 5, 6	R1 & R2
2	1c & 1d	13, 12, 11 & 10, 9, 8	R3 & R4
3	2a & 2b	1, 2, 3 & 4, 5, 6	R5 & R6

Table 2. Use of 74LS00 gates for the noise-free switches.

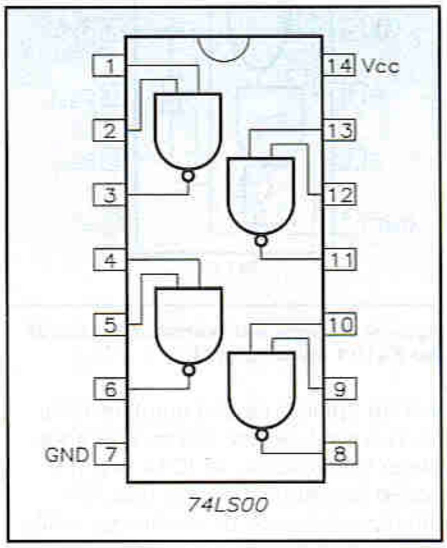


Figure 2. Pin-outs and internal schematic of the 74LS00 quad 2-input NAND gate IC.

and throughout the very short bouncing phase before $\overline{S}$ settles permanently in a low state, the Q output remains high.

Conversely, if the toggle switch is moved back to the Reset position, this makes $\overline{R}$ = 0 and $\overline{S}$ = 1, so Q = 0, i.e. it takes the output low.

Note that the prohibited combination of both inputs being simultaneously low is not encountered in this circuit, again provided that the common break-before-make type of switch is used.

An output can also be taken to the front panel from the output $\overline{Q}$.

TTL circuits are best protected against supply rail noise by liberal use of small decoupling capacitors, so a 100nF ceramic capacitor, C1, is included, wired closely to pins 7 & 14 of each IC. Note that the remaining half of IC2, if three switch circuits are made, remains available for another module, e.g., either the Push-to-Change or Inverter circuits.

Module 2: One-Shot Pulse Generator

This module provides clean, high and low output signals for about half a second, and its simple circuit is shown in Figure 3.

The 74121 is a versatile IC specifically for monostable or pulse generation. Its internal circuitry and pin-outs arrangement is illustrated in Figure 4.

There are several ways of configuring a 74121 to produce a single monostable pulse, including a variety of triggering methods. The circuit shown here takes advantage of an internal resistor connected between pins 9 & 11, which is externally supplemented by R2 and C1 in Figure 3 to give the required timing period.

Trial and error is probably the best way of choosing these timing components for a special case. Personally, when making timing circuits, I often have a specific capacitor at hand of the right type and roughly the right value, so I then choose a resistor by breadboarding the combination until I get the duration period about right.

The trigger input options of the 74121 include a pair of negative OR inputs at pins 3 & 4 ($\overline{A1}$ & $\overline{A2}$). In other words either pin 3 or 4 going low while pin 5 is high will trip the device. Alternatively these can both be tied low, allowing a positive going

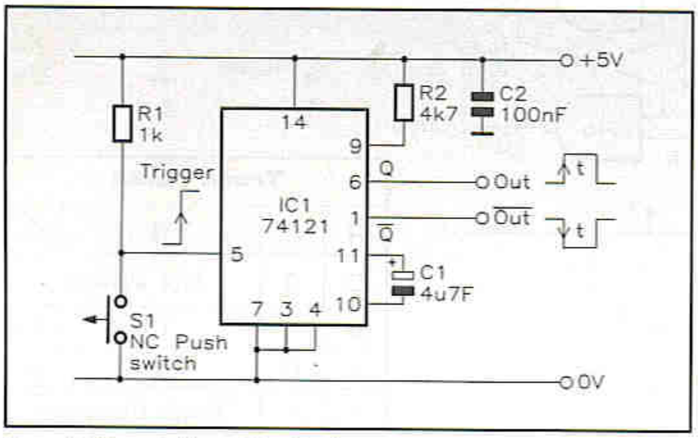


Figure 3. Monostable module circuit.

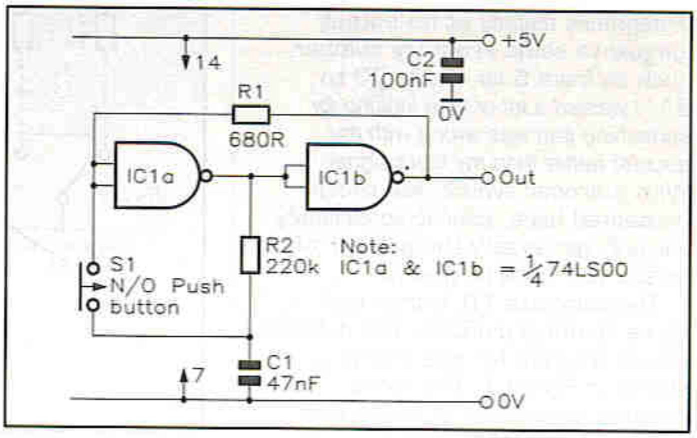


Figure 5. Push to Change Switch module circuit.

signal at pin 5 (called B) to trigger the device.

In this case the trigger is provided by a normally *closed* push-button switch on the panel, which produces a positive-going input signal when pressed. The necessary cleaning-up of this noisy triggering (taking account of switch bounce, etc.) is handled by the B input, which has a Schmitt input followed by a flip-flop, as shown in Figure 4. The flip-flop forms the monostable, which when tripped only stays in the set mode for the duration set by the R/C network. However, one useful feature of the 74121 is that this monostable can be retriggered before the time-out period expires and it will commence timing again from start.

Both Q (positive going) and $\overline{Q}$ (negative going) output pulses are available from the device. If any problems with retriggering are encountered when S1 closes on release of the button, a 100nF or 220nF capacitor can be connected across the switch contacts between R1 and 0V. Again a 100nF capacitor is provided for supply decoupling, C2, which should be connected as close as possible between pins 7 & 14 of the IC.

Module 3: Push-to-Change Button

Another useful module is this alternate action push button. Its output changes state each time the button is pressed, with debouncing and contact conditioning built-in. The circuit is shown in Figure 5.

Two gates of a 74LS00 Quad 2-input NAND IC are used as inverters. They are arranged so that, when the push button is pressed, the voltage on the capacitor C1 is transferred to the input of IC1a, and hence with further inversion and buffering via IC1b to the output. The capacitor stores the value (high or low) that

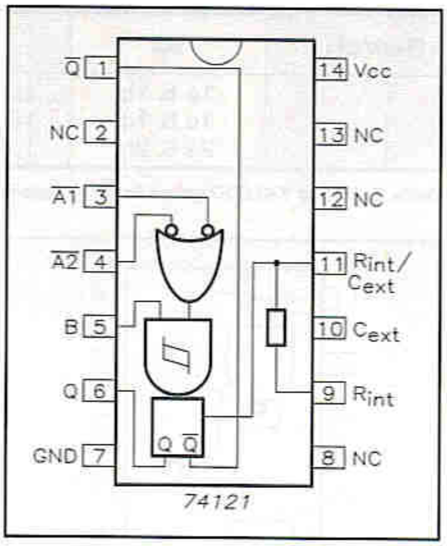


Figure 4. Pin-outs and internal schematic of the 74121 monostable IC.

will be applied to the input of IC1a on the next press. These are good clean transitions, as IC1a & b are wired together as a flip-flop. C1 cannot recharge or discharge while the switch remains closed, because the low value of R1 will hold it at the current level. When S1 is released, C1 is allowed to charge via the much higher value resistor, R2.

Note that the two other gates of IC1 may be unused if this module is to stand-alone. Otherwise they can be the two unused gates left over from the Noise-Free Switches module. Note also that C2 should be included if the module is stand-alone, having a dedicated 74LS00. Otherwise it is not needed as it is already included for that IC in the Noise-Free Toggle Switch module.

Module 4: Clock

For designing, testing and debugging TTL circuits you won't get very far without a reliable clock to generate repetitive pulses. To maximise versatility it must cover a wide frequency range. In this project the rotary switch allows the selection of five ranges, with potentiometer control within each of them. In practice the clock frequency can be varied from about 1 pulse every 30 seconds (2 per minute) up to 240kHz.

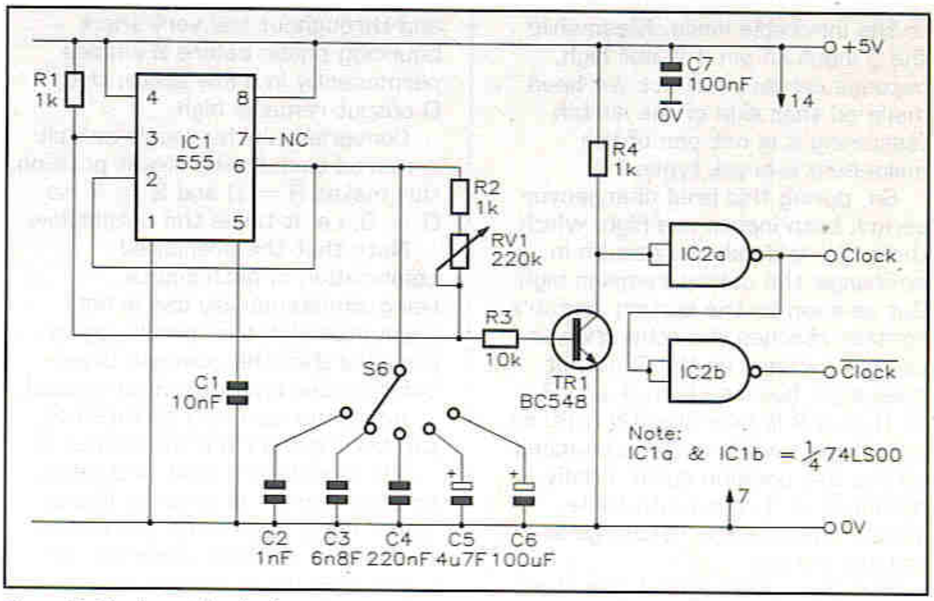


Figure 6. Clock module circuit.

After experiments with the 7413 and other TTL chips I concluded I couldn't get the wide range I needed. So I eventually settled on a 555 timer IC to form the basis of the clock circuit, which is shown in Figure 6.

The 555 timer has been available from a variety of manufacturers for more than fifteen years now, and is an extremely versatile IC, although there is no need for a constructor to be fully familiar with its internal circuitry.

The circuit in Figure 6 is a fairly basic astable configuration. The five timing range capacitors C2 to C6 are switched in by the rotary switch S1, and the individual control is through the potentiometer RV1 in series with R2. To ensure the output signal goes close to 5V, a pull-up resistor R1 is included. The additional transistor stage TR1, providing a buffered and inverted output, was added after discovering that loading the non-inverted output direct from pin 3 of IC1, even by as high a resistance as 1kΩ to ground, increased the output frequency significantly. From TR1 a TTL level non-inverted output is provided by one gate of a 74LS00 IC2a. A further inverted output is also provided, using a second gate following the first, IC2b. Note that the two other gates of IC2 may be unused if this module is to stand-alone and have its own 74LS00 IC. Otherwise they can be the two unused gates left over from another module. This IC can be shared by the Inverters (see Module 5).

The output pulses are not square, which is sometimes regarded as an ideal for clock signals, but in practice I have never found this to be essential.

Obviously the clock can be used for triggering TTL circuits which need either a positive-going or negative-going edge, as each pulse includes one of each! Sometimes it matters which one of these comes first. Normally, with high-frequency clocking, it won't be of any consequence.

But with a very low-frequency signal it might be important that the TTL circuit is triggered almost immediately on application of the clock signal, in which case some thought would be needed as to which edge was doing the triggering. The wrong choice could mean that an indeterminate time could elapse after the apparent application of the clock signal before the first triggering actually took place, which might give misleading results.

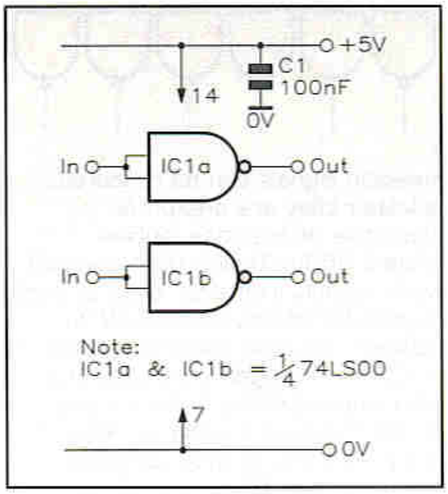


Figure 7. Inverters module circuit.

Unless you are aiming at a very high standard indeed, it is not usually worth the effort to get precise linear calibration, consistent across all ranges. In fact I suspect it would prove impossible, due to the large variation of some capacitors with temperature and age.

My five ranges overlap widely, so that in practice the entire frequency can be spanned. I calibrated the potentiometer dial roughly with a home-brewed frequency counter, plus a stop watch for the two low ranges. A summary of the frequencies and capacitor values is shown in Table 3 (below).

Module 5: Inverters

Occasionally it is handy to be able to change a high signal to low and vice versa. This module is simply two 74LS00 gates wired as inverters. It needs no explanation, but for completeness a circuit diagram is shown in Figure 7. The two NAND gates can be any spare pair from another module, e.g., the Clock. Otherwise if a dedicated 74LS00 IC is used, for a stand-alone module for example, then C1 is also required, fitted as close as possible between pins 7 & 14 of the IC.

Logic Level Testing Circuits

The four modules covered so far have all been signal generating circuits, whereas those that will be described now are for signal detection.

Three different types of logic level testing circuit were included. Although this was partly for my personal curiosity and learning, it also resulted in some practical advantages. Firstly, several different signals could be monitored simultaneously. Also, each of the three types has different

Frequency Range	1	2	3	4	5
Minimum frequency	0·033Hz	0·5Hz	10Hz	480Hz	3·7kHz
Mid-point	0·066Hz	1Hz	18Hz	1·8kHz	46kHz
Maximum frequency	3Hz	50Hz	1kHz	46kHz	240kHz
Capacitor	C6	C5	C4	C3	C2
Capacitor value	100μF	4μ7F	220nF	6n8F	1nF
Capacitor type	Tantalum	Elec.	Ceramic	Ceramic	Ceramic

Table 3. Timing capacitors and frequency ranges for clock circuit.

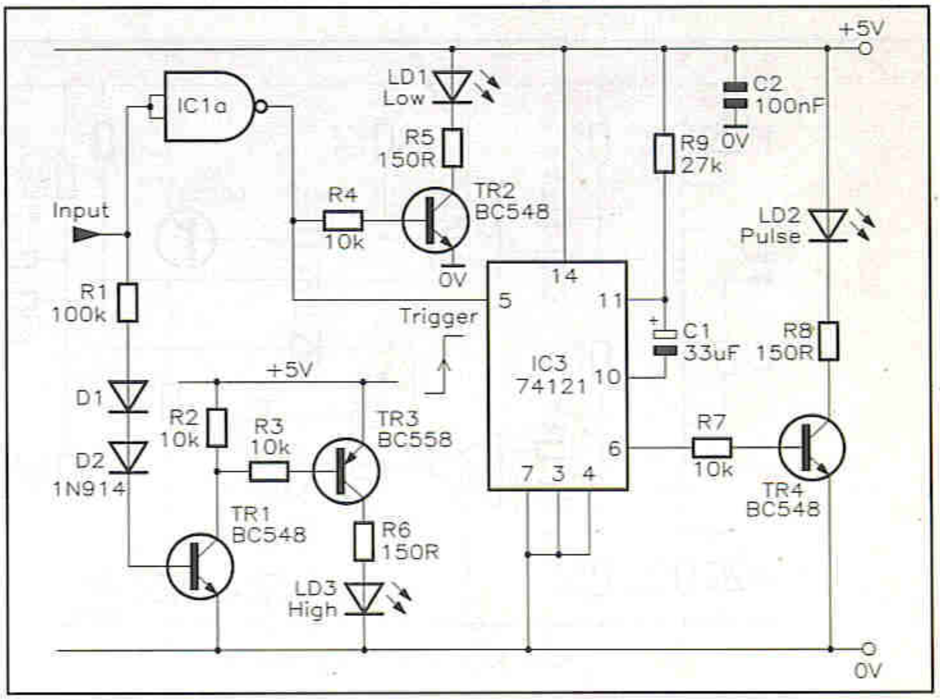


Figure 8. Logic Level Tester #1 circuit.

characteristics which were useful in their own right, as will be explained in the respective circuit descriptions. Furthermore, connecting a single TTL signal under test to two or three of the detectors simultaneously (that is in parallel) could sometimes be quite instructive, particularly when brief (and often unwanted) pulses were intermixed with regular counting or clocking signals.

Module 6: Logic Tester Type 1: High, Low and Pulses

The first of the three is the type most commonly encountered in professional TTL probes, see Figure 8, and includes a pulse indicator. Three coloured LEDs are used to discriminate between the three possible logic states: red for high, green for low and yellow for pulses.

If the input signal is higher than about 2·1V, then diodes D1 and D2 conduct, and NPN transistor TR1 is biased on, switching on TR3 and lighting the *red* LED, LD3.

On the other hand a low input takes the output of inverter IC1a high, lighting the *green* LED LD1 via TR2.

How about pulses? The 74121 monostable IC is used again, with its input options wired up for a positive going leading edge input, as was IC1 of the Monostable module.

If the input goes from high to low then, due to the inverting action of IC1a, pin 5 of IC2 goes high triggering the monostable, so *yellow* LED LD2, driven by TR4, lights for about one second. Very short duration signals can be detected, whether they are one-off or repetitive. In practice, pulses around 500ns (half a microsecond) were reliably indicated, even at peak amplitudes of only around 3V. In addition, because the monostable of IC2 is a retriggerable type, LD2 will remain steadily lit for as long as the pulses are present. Also, if the pulses are of short duration, the other two LEDs can indicate whether they are positive or negative going. For example, if the green LED also glows (perhaps dimly), then the input level is at logic 0 most of the time, with positive going pulses to logic 1.

Note that only one gate of the 74LS00, IC1a, is used in this module. The remainder can be used in another module, e.g., the Negative Pulse Indicator (see Module 9).

Module 7: Logic Tester Type 2: High, Low and Intermediate

TTL logic circuits like to see voltages which are either below about 0·8V, which is regarded as Low, or over about 2·4V, which they take to be High. Signals in between these thresholds have an effect on TTL rather like that of boxing gloves on a pianist. The circuit is shown in Figure 9.

This, the second of the three logic testers, includes an indicator showing when the input is in this forbidden territory. It uses three of the four comparators in a 3900 quad Norton op amp. This is a rather unusual IC which, unlike a conventional op amp, amplifies the difference in input currents rather than input voltages. Incidentally, an equivalent IC, which you might occasionally come across, having identical pins and similar specification, is the 3401.

The test voltage is applied in parallel to the two comparators IC1a and IC1b. Their other inputs are set to reference voltages derived from the voltage divider R4, R7 & R10. With the values shown these establish the lower threshold at 0·8V and the higher one at 2·4V.

If the input is logic low, then the output of IC1a will remain high, but that of IC1b will go low, switching on the green LED LD1. If the input is high the reverse happens, i.e. IC1a goes low and IC1b remains high. In either case clamping diodes D1 or D2 hold off IC1c, the intermediate indicator stage.

If the input falls within the gap between these valid logic levels then neither comparator IC1a nor IC1b will go low, i.e. both will be high. So the input to IC1c at pin 13 will be close to 5V, while its other input will be about 2·5V, set by voltage divider R18 & R21, so the output at pin 9 will go high, driving on TR3 and lighting the yellow LED LD3. In this case an invalid intermediate state will be shown. This is possible where for example a logic line is open circuit, or a device with 3-state outputs is in its 'high impedance state', i.e. its outputs are not enabled. (3-state devices are most commonly found in microprocessor systems, but can appear in more modest logic circuits.)

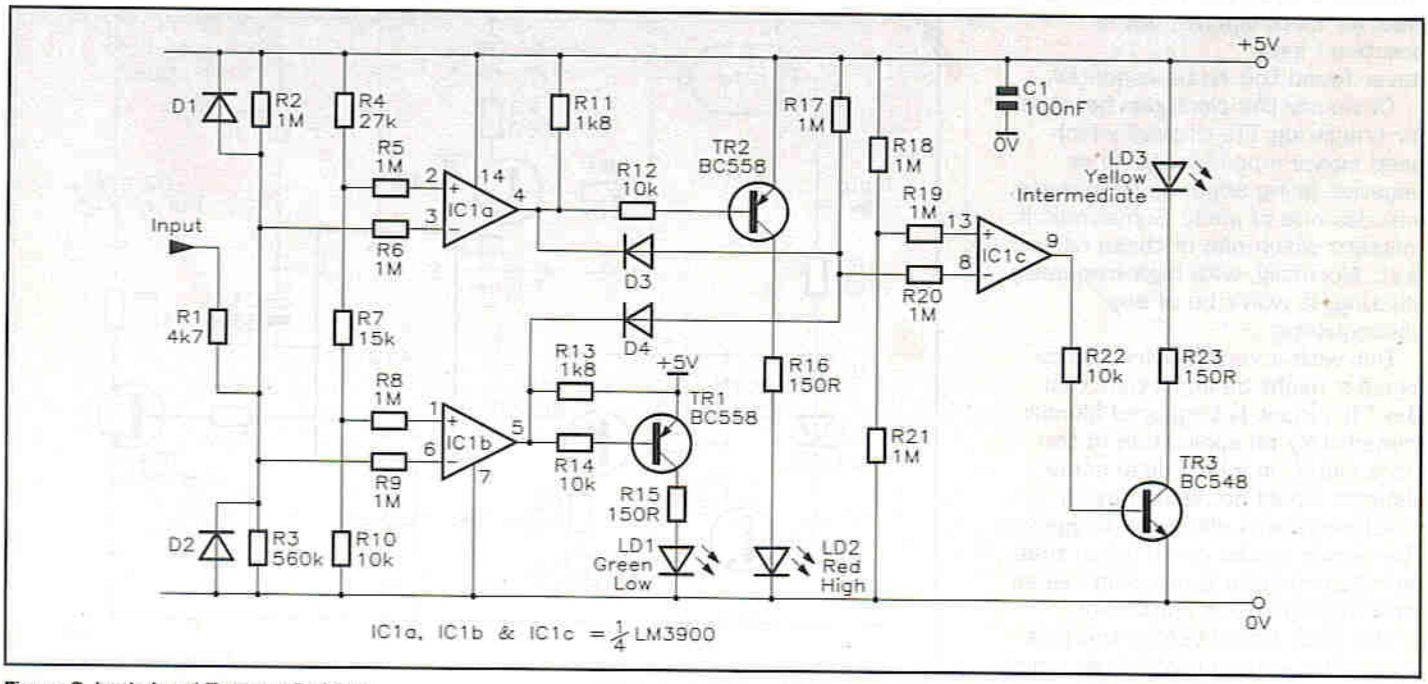


Figure 9. Logic Level Tester #2 circuit.

Module 8: Logic Tester Type 3: Simple High and Low

By contrast, the third tester circuit is a very simple one, making use of the one comparator left over in the 3900. It just shows high and low states, which are set nominally at a threshold of about 2V. Although this is not strictly accurate as far as the TTL specification is concerned, it is still useful for most general purposes.

The circuit's operation is very straightforward and it is shown in Figure 10. The input is compared, by comparator IC1a, with the voltage at preset RV1, nominally set to 2V. If the signal is higher than this then pin 10 goes high. This turns TR2 on, effectively shorting out LED8. TR1 is off because its base is high, so red LED LD7 passes current via TR2, indicating a high level.

Conversely if the input is low, TR1 is on, TR2 is off and LD2 lights.

Module 9: Negative Pulse Indicator with Manual Reset

This final module has proved extremely useful for detecting otherwise elusive signals and intermittent spikes. Negative-going pulses shorter than 100ns can be detected, possibly very much shorter; in fact that is the narrowest setting of my home-brewed signal generator, so I was unable to measure its lower limit.

The circuit is shown in Figure 11. The pulse indicator section is just a standard dual NAND gate bistable, and the low-going input signal takes the output high, lighting the red LED. The bistable action causes this state to be latched on until reset. So if, for example, you suspect a circuit under test to be malfunctioning because of spikes or glitches, then you can use this module to check for negative pulses. To test for positive going pulses the module could be preceded with one of the inverters.

If, when you first connect an input signal, the indicator comes on at once then it is probably because the input is already static at a low TTL logic level. You will need to either reconnect the tester to a different part of the circuit under test, or take it through one of the inverters.

The bistable is reset by S1, but to work properly the input must be logic high or open circuit. A train of pulses can be verified by repeatedly resetting the detector; if the LED always relights then the pulse train is present.

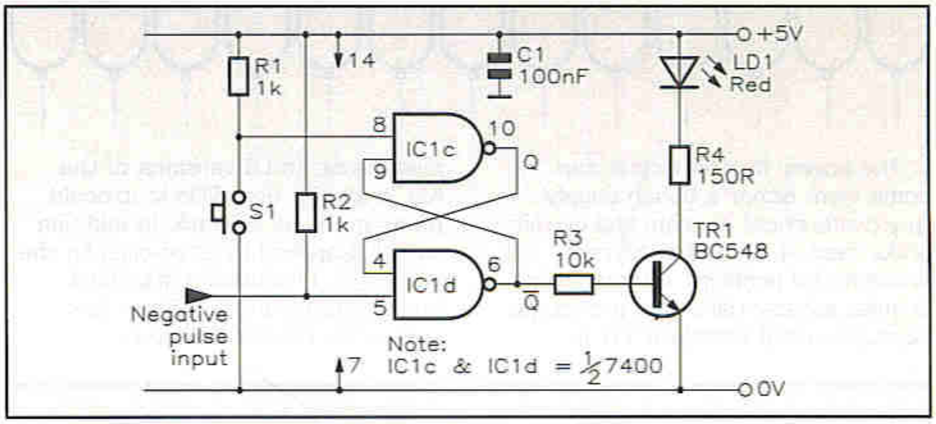


Figure 11. Negative Pulse Indicator circuit.

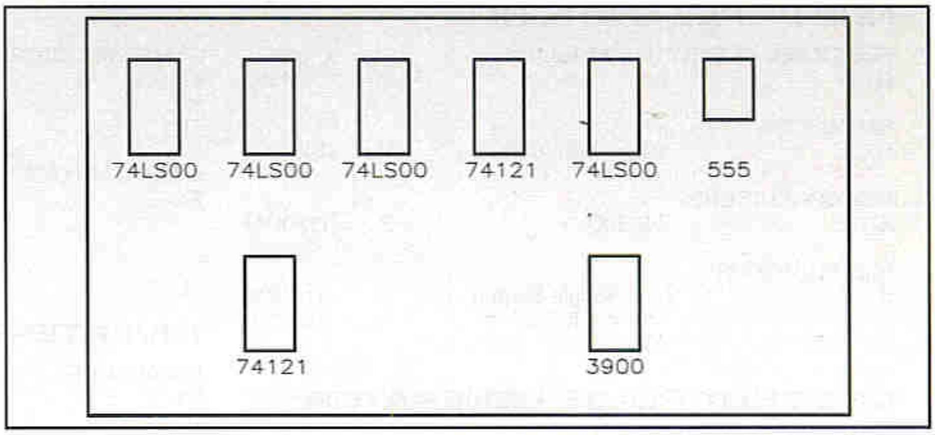


Figure 12. Suggested layout of stripboard for complete TTL Tester Unit.

Construction

I have not provided detailed construction instructions, as there is so much flexibility in the modules you might want to include, and wide scope for personal customisation over the type and size of the case and connectors.

The prototype was constructed inside a plastic fishing tackle box, but the Maplin range of cases includes many superior modern alternatives. My circuit was made on a rectangular piece of 0·1in. stripboard measuring about 2·1in. by 5in., and an approximate layout of the ICs is shown in Figure 12. Alternatively plain matrix board can be used and the component wires soldered together underneath. Always use IC sockets as this takes the strain off the ICs themselves during soldering. No detailed wiring layout is provided; simply follow and double-check against the circuit diagrams.

A fundamental design decision taken at the outset was to use test leads with croc clips (and other sprung probes of various types) to get signals to and from the unit. There were various choices of connector for inputs and outputs, but I eventually settled for using 18swg tinned copper wire. Each of these was shaped to lengths of about half an inch (longer for the power rails) and then inserted through small holes drilled in the panel. A touch of resin-epoxy glue was added but was probably unnecessary given the deliberately chosen tight fit.

Wires were soldered easily from these to the stripboard.

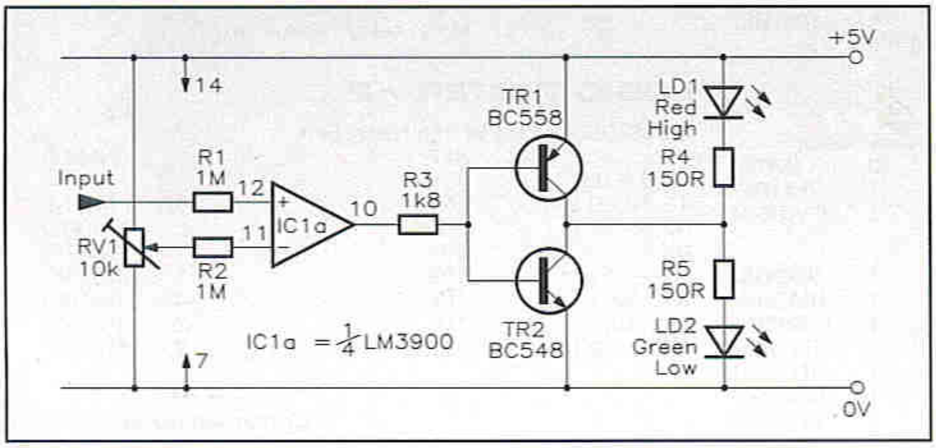


Figure 10. Logic Level Tester #3 circuit.

The power for the circuit can come from either a bench supply (my preference) or from the circuit under test, if the extra current presents no problem. Consumption is quite substantial in the prototype because I used standard TTL in preference to LS versions of the ICs, and with five LEDs lit it could be as much as 270mA. In addition to being applied by croc-clips to the wire rails, I included a standard phono socket and a 3·5mm jack socket for the 5V DC input. Preferably, a 47μF electrolytic supply decoupling capacitor should be included on the board at the point where the DC power comes in.

My unit is now nearly ten years old and still giving good service. I hope yours proves just as useful.

PARTS LISTS

NOISE-FREE SWITCHES

RESISTORS: All 0·6W 1% Metal Film.			
R1-6	1k	6	(M1K)
CAPACITORS			
C1,2	100nF Disc Ceramic	2	(BX03D)
SEMICONDUCTORS			
IC1,2	74LS00	2	(YF00A)
MISCELLANEOUS			
S1-3	Min. Toggle Switch	3	(FH00A)
	14-Pin DIL Socket	2	(BL18U)
	Wire, solder, stripboard.		

ONE-SHOT PULSE GENERATOR

RESISTORS: All 0·6W 1% Metal Film.			
R1	1k	1	(M1K)
R2	4k7	1	(M4K7)
CAPACITORS			
C1	4μ7F 63V PC Electrolytic	1	(FF03D)
C2	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	SN74121N	1	(QX73Q)
MISCELLANEOUS			
S1	Push to Break Switch	1	(FH60Q)
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard		

PUSH-TO-CHANGE CIRCUIT

RESISTORS: All 0·6W 1% Metal Film.			
R1	680Ω	1	(M680R)
R2	220k	1	(M220K)
CAPACITORS			
C1	47nF Disc Ceramic	1	(BX02C)
C2	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	74LS00	1	(YF00A)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard		

CLOCK

RESISTORS: All 0·6W 1% Metal Film (Unless specified).			
R1,2,4	1k	3	(M1K)
R3	10k	1	(M10K)
RV1	220k Rotary Linear Pot	1	(FW06G)
CAPACITORS			
C1	10nF Disc Ceramic	1	(BX00A)
C2	1nF Monolithic Ceramic	1	(RA39N)
C3	6n8F Monolithic Ceramic	1	(RA43W)
C4	220nF Monolithic Ceramic	1	(RA50E)
C5	4μ7F 63V PC Electrolytic	1	(FF03D)
C6	100μF 10V Tantalum	1	(WW79L)
C7	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	NE555N	1	(QH66W)
IC2	74LS00	1	(YF00A)
TR1	BC548	1	(QB73Q)
MISCELLANEOUS			
S1	2-Pole 6-Way Rotary Switch	1	(FF74R)
	8-Pin DIL Socket	1	(BL17T)
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard.		

INVERTERS

CAPACITORS			
C1	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	74LS00	1	(YF00A)
MISCELLANEOUS			
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard.		

LOGIC TESTER #1

RESISTORS: All 0·6W 1% Metal Film.			
R1	100k	1	(M100K)
R2,3,4,7	10k	4	(M10K)
R5,6,8	150Ω	3	(M150R)
R9	27k	1	(M27K)
CAPACITORS			
C1	33μF 35V PC Electrolytic	1	(JL14Q)
C2	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	74LS00	1	(YF00A)
IC2	SN74121N	1	(QX73Q)
TR1,2,4	BC548	3	(QB73Q)
TR3	BC558	1	(QQ17T)
D1,2	1N914	2	(QL71N)
LD1	Red 5mm LED	1	(WL27E)
LD2	Yellow 5mm LED	1	(WL30H)
LD3	Green 5mm LED	1	(WL28F)
MISCELLANEOUS			
	14-Pin DIL Socket	2	(BL18U)
	Wire, solder, stripboard.		

LOGIC TESTER #2

RESISTORS: All 0·6W 1% Metal Film.			
R1	4k7	1	(M4K7)
R2,5,6,8,9,17, 18,19,20,21	1M	10	(M1M)
R3	560k	1	M560K)
R4	27k	1	(M27K)
R7	15k	1	(M15K)
R10,12,14,22	10k	4	(M10K)
R11,13	1k8	2	(M1K8)
R15,16,23	150Ω	3	(M150R)

Continued on next page

Continued from previous page

CAPACITORS			
C1	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	LM3900	1	(QH42V)
TR1,2	BC558	2	(QQ17T)
TR3	BC548	1	(QB73Q)
D1,2	1N914	2	(QL71N)
LD1	LED Green 5mm	1	(WL28F)
LD2	LED Red 5mm	1	(WL27E)
LD3	LED Yellow 5mm	1	(WL30H)
MISCELLANEOUS			
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard.		

LOGIC TESTER #3

RESISTORS: All 0·6W 1% Metal Film (Unless specified).

R1,2	1M	2	(M1M)
R3	1k8	1	(M1K8)
R4,5	150Ω	2	(M150R)
RV1	10k Hor Enclosed Preset	1	(UH03D)
SEMICONDUCTORS			
IC1	LM3900	1	(QH42V)
TR1	BC548	1	(QB73Q)
TR2	BC558	1	(QB17T)
LD1	Green 5mm LED	1	(WL28F)
LD2	Red 5mm LED	1	(WL27E)
MISCELLANEOUS			
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard.		

NEGATIVE PULSE INDICATOR

RESISTORS: All 0·6W 1% Metal Film.

R1,2	1k	2	(M1K)
R2	10k	1	(M10K)
R4	150Ω	1	(M150R)
CAPACITORS			
C1	100nF Disc Ceramic	1	(BX03D)
SEMICONDUCTORS			
IC1	74LS00	1	(YF00A)
TR1	BC548	1	(QB73Q)
LD1	Red 5mm LED	1	(WL27E)
MISCELLANEOUS			
S1	Push to Make Switch	1	(FH59P)
	14-Pin DIL Socket	1	(BL18U)
	Wire, solder, stripboard.		

The Maplin 'Get-You-Working' Service is not available for this project, nor for any of its separate modules.

The above items are not available as a kit.

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19.	(-)	NEW ENTRY	2·5W Audio Amplifier	VE12N	£8.95	Catalogue	'94 (CA11M)
20.	(-)	NEW ENTRY	Electronic Siren	LP97F	£3.95	Magazine	53 (XA53H)

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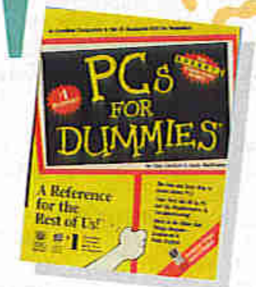
PCs for Dummies

by Dan Gookin & Andy Rathbone



As with other titles in the 'Dummies' series, this book is designed for those people who wish to do the job and not to become computer geniuses. This book is more a reference as each topic is independent and can be read in isolation – cross references are provided for the times when further information is required. Everything you need to know about your PC is covered in the text, except information on using the software and using DOS.

It is a fact of life that there is a lot of technical information involved in using a computer. Where it was felt necessary to include such information, then the text is clearly marked. However, it is not a requirement to read the technical information and it may be ignored, but it will provide substantial information about your PC.

Part 1 contains basic computer information and includes setting up a computer, getting help and understanding common computer phrases. Part 2 covers specific parts of a computer and includes a chapter on laptops. Part 3 deals with using DOS, software, Windows, networks and much more. Part 4 is a summary and contains a host of hints, tips, suggestions and other useful facts, neatly arranged into convenient chapters.
1992. 395 pages. 235 x 188mm, illustrated. American book.

Order As AA63T
(PCs For Dummies) ***£14.99 NV***

Beam Antenna Handbook

by William I. Orr and Stuart D. Cowan

The radio spectrum is a small portion of the electromagnetic spectrum and the DX radio amateur is more concerned with bands covering 1·8MHz and 50MHz. It is in this region that radio communication over long distances takes place.

Before the last World War constructing a rotary beam aerial was a very tedious job, but since then, the rotary Yagi beam has attained an important place in the world of radio communication. The authors have for many years been keen enthusiasts of the design, and all their experience and knowledge, and others has been combined into this informative handbook.

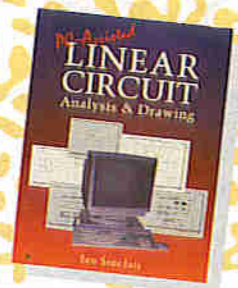
This handbook covers all aspects of HF and VHF Yagi antenna design. Information on construction, installation, testing and operation of these aerials is included along with the effects of element taper, mounting hardware and matching systems. The twelve chapters cover topics ranging from radiation and propagation antenna, transmission lines, matching the antenna to the line through to antenna test instruments. This is in addition to the many antenna designs that are featured in this book including computer derived designs for high gain antenna for the HF and VHF bands. Dimensions are conveniently provided in both English and metric measurements, along with scaling information that permits many designs to be used on frequencies outside the amateur bands.

This attractively priced book is a must for all amateur radio enthusiasts.
1990. 272 pages. 233 x 186mm, illustrated. American book.

Order As AA59P
(Beam Antenna H/Book) ***£7.50 NV***

PC-Assisted Linear Circuit Analysis & Drawing

by Ian Sinclair



In the past, analysis of linear circuits used to be a long and tedious process, requiring many repetitive calculations – a task that was not very easily undertaken by the amateur. Even the professional engineer found such calculations tedious and off-putting. Even if a formula exists, passive and filter circuits can still present considerable problems, for often small deviations from the circuit are not allowed for in the calculations. The problem becomes one of analysing the system from first principles. If you have access to a PC, then the problem disappears when a linear analysis program is run. Circuits can be analysed in terms of amplitude and phase response over a wide frequency range, and the effect of tolerances can also be considered.

This book introduces the principles and explains what is required to analyse a variety of common circuits, by following a large number of examples. In addition, the effects of stray capacitance, and source and load resistance values are illustrated.

The book uses Aciram and Autosketch as example software. By using a low-cost CAD program such as AutoSketch, it is possible to automate the process producing precise and printable circuit diagrams of a very high standard.

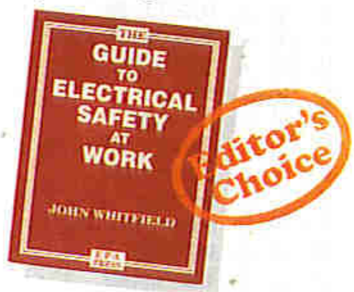
The book is not aimed at the absolute beginner to linear circuits, but will be of interest to the student, the technician or engineer, the interested amateur and anyone involved with linear circuit development work. A basic knowledge of computers is assumed, although a more detailed knowledge of electronics is obviously required.
1993. 280 pages 246 x 189mm. Illustrated.

Order As AA62S
(Lin Circuit Analysis) ***£14.95 NV***

The Guide to Electrical Safety at Work

by John Whitfield

The Electricity at Work Regulations 1989 became effective in Great Britain on 1st April 1990 and in Northern Ireland on the 1st January 1992. The purpose of the regulations is to ensure that all necessary precautions are taken in work related activities to prevent death or personal injury from electricity. They are statutory Regulations made under the Health and Safety at Work Act 1974. In simple terms what this all means is that electrical systems must be safe for those using them – electrical installations must comply with the regulations for Electrical Installations, as published by the IEE. This guide explains the relevant regulations in detail and in an easy to understand manner. It is important to realise that the regulations do apply to houses. Anyone at work in a house, for example installing electrical installations, extending or repairing it, or even repairing or servicing electrical appliances, is *at work* and is thus subject to the Regulations.



This book is intended to answer questions that are likely to arise for people at work who need to know about the Regulations. The employer and self-employed will find this a very useful book to have permanently to hand. Equally, the employed person will find the book extremely useful. The material has been presented in a non-technical manner so that the book will be useful for all. Highly recommended.
1992. 142 pages. 197 x 142mm, illustrated.

Order As AA64U
(Guide Elect Safety) ***£9.95 NV***

Outsourcing and Facilities Management

by Frank Booty

Today, organisations are increasingly questioning whether their in-house EDP (Electronic Data Processing) functions are delivering the information systems and the cost-effectiveness that today's competitive business climate requires. 'Outsourcing and facilities management' is a solution that allows organisations to hand over some or all of their computing-related functions to third parties, thus restoring cost-effectiveness and organisational flexibility.

'Outsourcing' literally means looking to contract the execution of a service outside a company. The decision to outsource a service or activity becomes more charged, however, when it also means discontinuing an activity formerly carried out with the company's own means and resources (in-house), and buying it from third parties. This is particularly so for computing activities hitherto considered so vital, strategic or confidential that they could only be carried out in-house, but which are now increasingly being put out to third parties.

Traditionally EDP services have been kept in-house, protected more by the conviction that it is inconceivable to contract them out than by any considered aversion to outsourcing. However, the continuance of an in-house EDP activity, against a background of constant technological development and organisational change, requires that a company constantly reviews its EDP activity and attempts to contain rising costs. This means expending financial and professional resources on an activity that, although essential, provides only a support function to a company's real business operations.

The company can subcontract activities not considered to be differentiating for its position in the market, allowing it to concentrate the available resources on its own core business. These non-differentiating activities do not contribute in an obvious way to the company's image, but this does not mean that their quality, effectiveness and efficiency are any less important. On the contrary, the company that decides to outsource an activity should pay particular attention to obtaining the best service to cost ratio, for the optimisation of these non-differentiating activities plays an important role in giving a company its competitive edge.

Reasons for Outsourcing

But why outsource? One most immediate stimulus for a decision to outsource is dictated by short term financial considerations. In particular, the opportunity to transform much of a company's fixed costs into *variable* costs, which should then keep pace with a company's evolution, is a powerful argument indeed. But there are other internal factors that prompt a company to consider outsourcing. These include the need for greater flexibility in a company's Information Technology (IT) resources, a reduction in an organisation's operational levels, the geographical spread of organisations, the increasing rate of change in practically all business operations, and the speed of technological development, which makes it difficult for in-house EDP staff to keep abreast of the latest trends.

Unless there are special factors, outsourcing only has economic attractions where the outsourcing supplier's organisational and technological scale is superior to that of the client. If the client organisation is of a comparable size, it may prefer to continue to search in-house for economy, effectiveness and efficiency. The best reason for using outsourcing, and the one that also provides the highest probability of success, is the desire to concentrate on using technology strategically, to remain competitive in one's own business sector. By shaking off the burden of daily technological problems, the company has more time to dedicate to its technological partner and attain, with their collaboration, a more effective understanding of how technological products and services, both current and innovative, can be used to formulate the company's business strategy.

The correct attitude is to recognise that outsourcing is a one-way street and essentially comprises the definition and management of a medium to long term relationship. This means that the two parties must be able to work together in agreement on strategic decisions, rather than on the more traditional basis of a customer and supplier relationship. The stability and success of the relationship is not ensured by a contract alone. Outsourcing places the emphasis on a collaborative approach regarding strategic planning and the management of change. The supplier of the services is called the 'outsourcing partner' and must be chosen not just for its size and technical skill, but also for other aspects such as financial structure, shareholder solidity, management capability and capacity, etc.

How it Works

Figure 1 shows a basic outsourcing structure. The supplier achieves economies of scale, offering a range of resources to a number of clients at favourable prices. The supplier's other great ability is that of planning, and here the customer must acknowledge that collaboration with the supplier in this planning activity is both essential and to its advantage.

So, should a company consider outsourcing or facilities management? Although just about any EDP function can be dealt with by outsourcing, initially users may be reluctant to contract out strategic functions, such as design and maintenance of information systems, or to stipulate a partnership covering the whole management of information technologies. A more gradual approach, with less ambitious objectives, is that of facilities management (Figure 2a).

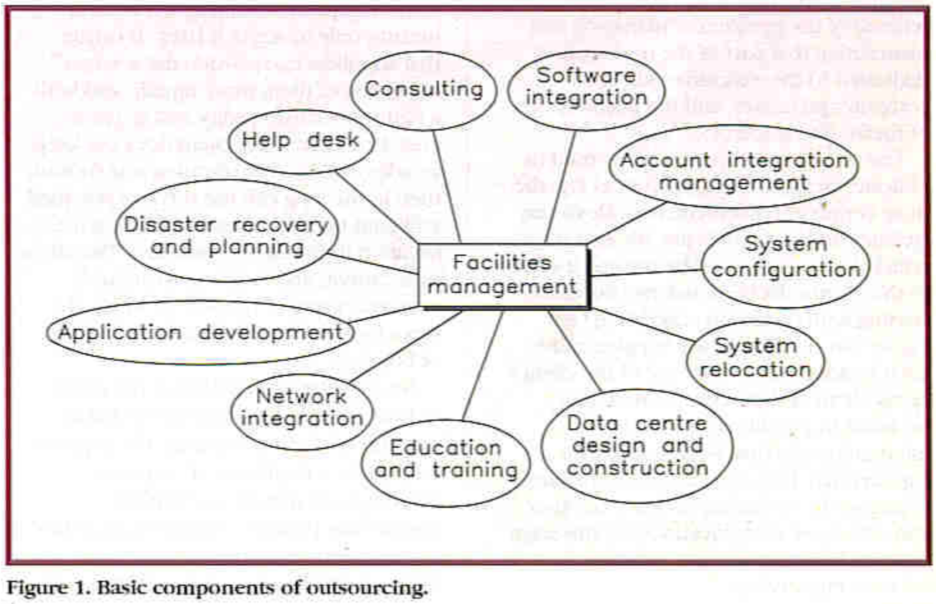


Figure 1. Basic components of outsourcing.

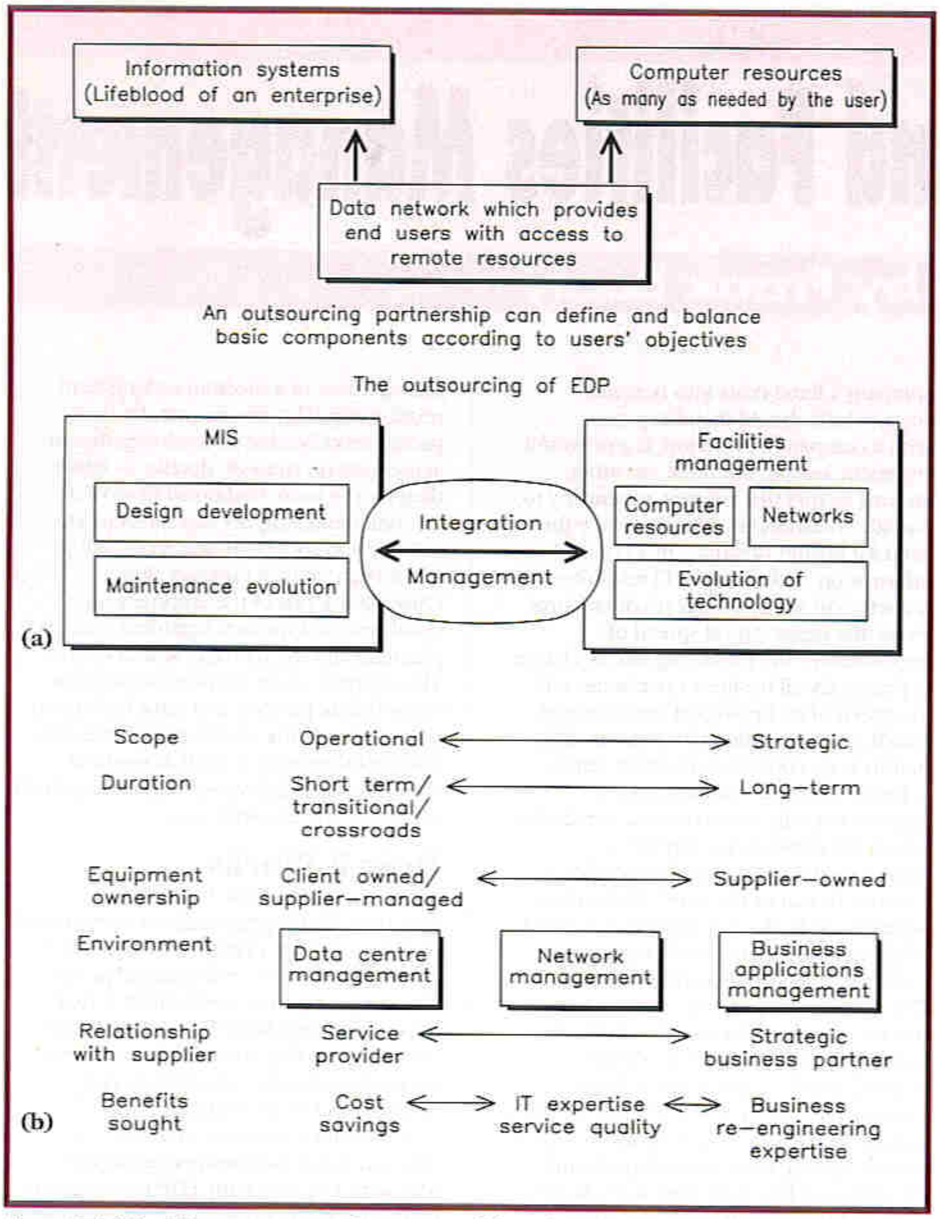


Figure 2: (a), Facilities management is not a standalone business; (b), customers face a range of options.

Here, the supplier takes over the operational side of the client's EDP function, providing the technological and organisational infrastructure to carry out the processing, but which the client continues to control, providing the input and planning the processing activities. Thus the client is relieved of the problem of managing and maintaining that part of the organisation dedicated to the executive side of its computer processes, and the maintenance of means and resources.

The term 'outsourcing' is often used to indicate 'facilities management', as it is the most common implementation. However, facilities management is just the first stage, which can be enhanced by moving it closer to the client's decision making processes, starting with operation scheduling (see Figure 2b). To do this, the supplier must have an adequate knowledge of the client's applications and processes, and might be asked to provide maintenance of information systems. Subsequently the supplier may help the client to formulate objectives by operating also as a designer and developer of applications. By this stage, the supplier is providing a *complete* outsourcing service.

External EDP in Practice

A common belief is that a company moving to outsourcing must surrender management of a good part of itself, but nothing could be further from the truth. The desire to free oneself of a series of problems leads some companies to relinquish control initially, only to regret it later. It is true that suppliers can provide the services requested of them more rapidly, and with a better objective quality and at a lower cost. However, if the client does not keep an adequate level of planning and control, then in the long run the services provided will tend to lose contact with the actual situation in the client's business. The client thus cannot, and must not, relinquish *understanding* of the way in which the services brought in add value to its line of business.

No supplier will encourage the client to lose interest in the operations being outsourced. On the contrary, the supplier will ask for a definition of prepared, unambiguous interviews with the appropriate powers of decision. Facilities management, and outsourcing even more so, involves a complex structure of services, resources and professionalism, the composition and equilibrium of which must be known and accepted by the client. The ideal client is the one who knows whether he is satisfied or not, knows why, and who works to create and maintain the reciprocal in-depth knowledge that is the basis of an enduring relationship.

To pursue a policy of outsourcing is a one-way, no return journey. Anybody ridding itself of its own in-house computing centre in favour of a facilities management solution would meet considerable difficulty if, later, it wanted to return to in-house processing, which would have to start from scratch again. Outsourcing is generally defined in the perspective of medium or long term relationships, as these allow both parties to benefit from the accord more easily. Facilities management contracts can be short term in most instances, and this is a good way of dealing with transitional situations.

A typical (generally short term) transition is that of 'operating systems migrations,' that is, a changeover from one system to another. For this event, the availability of an alternative computing service is ideal for managing the period of overlap between the two environments. A transitional solution is also desirable in the processes known as 'downsizing.' Here, a company with an internal EDP operation based on a mainframe computer may recognise that its activities are progressively reducing ('downsizing'). The problem is that the costs of the in-house mainframe resources do not reduce by a similar proportion, and the term 'downsizing' is then used to indicate the radical decision to replace a large mainframe based environment with one or more environments of a smaller technological scale (PCs, for example). For the client organisation, which has to convert from mainframe technology to minicomputer technology, the facilities management approach offers important benefits in the most critical migration phase.

There are two potential uses of facilities management here. First, the migration and conversion of applications from one technological platform to another are not immediate. The client might have two environments needing to be managed for a significant period of time, as the old one cannot be abandoned without first having started up and sufficiently stabilised the new one. The second aspect is that the mainframe environment might not be totally cancelled (because of the high costs of database conversion, for example) and so the mainframe would need to be retained, largely under-utilised but nonetheless still necessary.

Summary So Far

Outsourcing and facilities management provide a flexible set of responses to organisations that need to run mainframes, but do not want the headaches of a full function, in-house EDP operation. Put simply, outsourcing and facilities management provides customers with mainframes where necessary, for as long as is necessary, and with costs proportional to their use.

The Advantages of Outsourcing

Today, many corporations are undergoing restructuring and are subject to phenomenal regulatory changes, which alters the ground rules of their operations almost daily. They are entering an era of global competition, which offers not only enormous opportunities but also considerable dangers. Organisations also face tremendous technological changes. Simultaneously, the strategic value of information has never before been held in such high regard. The task now is to gather that information, give it to the people who need it and provide it promptly in an understandable format.

Such factors are driving organisations toward a more federated structure. They want to concentrate on what they are good at – their core businesses, and leave the rest to someone else. Catering requirements can be farmed out to other organisations. Vehicle fleet maintenance is another example.

Companies have different perceptions of where peripheral business ends and core business begins. Some companies outsource parts of their operations that outsiders might think are core. For example, the Ford Motor Co. in the US decided it no longer wanted to build engines, so it has contracted Japan's Mazda to build them.

In the beginning, most large organisations' first experience of Information Technology (IT) was as an outsourced resource in the form of large computer bureaux that managed their payrolls. The computer was seen as a service, not as another item of office equipment to learn how to use and manage. Then came the in-house bureau, the mainframe. It was soon followed by the minicomputer and then, in the 1980s, by the microcomputer. As the processing units got smaller and more distributed around an organisation, the communications links between units became more important. That meant the growth of the private network.

The trend now is to look again at IT as a set of services. The main difference is that, with the advent of distributed computing, the communications network is today's computing facility. Many factors deter users from running their own private networks. For one, doing so has become very expensive. It has also become a complex task, so quality levels can be unpredictable. But in many cases users were forced to build their own networks in the first place, because nobody else would do the job for them. However, outsourcing network management needs can save users' money, offer greater operational flexibility and allow the deferral of substantial capital investments.

Outsourcing is a term that has come to mean 'the contracting out by a customer to a third party of the management responsibility, and sometimes the ownership, of the IT infrastructure.' This includes installation activities, day to day management, resources, budget and personnel. The majority of revenues earned by outsourcing vendors comes from data centre operations. Outsourcing services can take a variety of forms depending upon who owns the hardware assets and where the processing is done. If the vendor owns both the hardware assets and the application software, then the services are classified as transaction processing, rather than facilities management or outsourcing.

The originally outsourced IT service is probably applications development, with programming bureaux hiring out skilled programmers on a time basis ('bodyshopping'). The outsourcing of selected operations, like payroll processing, moved the market further along. However it was probably the case of IBM securing the facilities management contract for all of Kodak's data processing in the US that defined the latest wave in the outsourcing market.

Today, outsourcing contracts usually include other professional services such as 'help desk' and education and training. Increasingly, customers and vendors have recognised the value of including business process maintenance in with the responsibilities of the IT provider. The market today includes a variety of contract arrangements in scope, duration, IT environments, relationships sought and (most importantly) the benefits sought.

Making a Deal

Successful outsourcing, such as with IT, has to do with shared interests and returns. When Ford decided to farm out its engine production to Mazda, for instance, it took a 25% stake in the Japanese company. Similarly, an outsourcing company might buy a private network from a user. The user would get immediate revenues and take assets off their books. The outsourcing company would manage the user's network.

Building a relationship between an outsourcing company and a user is a complex task. After all, the user is handing over the running of part of its business to an outsider. It can take up to two years to negotiate a managed network outsourcing deal. Even then, most users would not hand over the complete running of their networks all at once. The first phase of outsourcing usually involves a three to five year commitment to manage the extension of an existing network. But this is the beginning of a relationship that will probably last 20 years or more. Selecting a network outsourcing partner is a decision that a user is unlikely to make more than once every couple of decades.

An outsourcer has to convince users of its experience in managing communications networks, its financial stability and its commitment to the network management business. Users also need assurance that the outsourced resource can be operated to satisfy their needs.

Another user requirement is that the outsourcer understands the user's business and its applications. What is more important is that users will want to know that the performance criteria agreed are based on results laid out in the user's terms, not in system jargon. Setting up a Service Level Agreement (SLA) is therefore the key to this process. SLAs will reflect the different priorities of organisations. A soft drinks company may be particularly keen to ensure that its network performs at its best when the sun shines. A bank will probably want to see its automatic teller machines given the best network support during lunch breaks and in the evenings. In particular SLAs should cover delivery, performance and fault prioritisation. They should also cover the hand over procedures between the private and the managed network.

Although each company's reason for outsourcing is different, there are some motivations that recur, and these fall into the three categories of financial, technological and human resources.

An example of the financial motivation is the desire to cut costs. A typical UK-based,

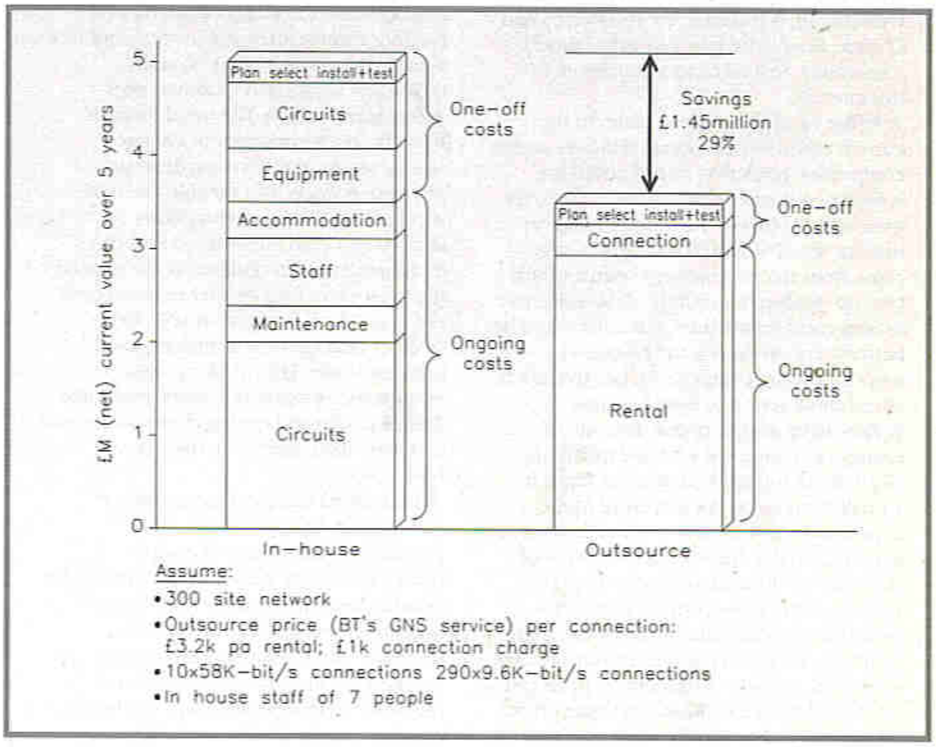


Figure 3. Cost advantage of outsourcing.

300 site private network, which would cost £5 million to run over five years as an in-house system, could cost £3·5 million as an externally managed network (see Figure 3). Equally important financial motivations may be the desire to have fixed and predictable costs for budget planning, and the desire to benefit from the boost to the balance sheet derived from an outsourcing package. This includes the purchase of assets such as an existing private network.

A technological motivation could range from the ability to benefit from new technology (or to avoid obsolescence), achieving a more integrated level of network management.

A human resource benefit could be the better use of skilled and scarce staff to meet internal users' IT needs. Improved project management is another possible motivation.

Outsourcing allows organisations to respond more flexibly and rapidly to change. A business acquisition, a new application or a new geographical area to cover, can all require rapid expansion of the network. These scenarios may be difficult for an in-house operator to respond to. On the other hand, managing the contraction of a private network can also be a difficult task.

Market Participants

The players in the outsourcing and facilities management market are many, and range in size from single customer shops to multi-billion pound corporations and partnerships. Some vendors specialise in particular 'vertical' markets, such as financial services. Others concentrate on particular platforms such as IBM mainframe computers. Still others are generalists, operating in multiple industries across a variety of platforms. Companies who typically offer business in this market are BT, EDS, AT & T Istel, Perot Systems, Digital, IBM, Sema Group, Infonet, Unisource, Sprint and MCI.

Market Size

The scope of outsourcing contracts causes some difficulty in defining the market size and projecting forecasts. One researcher, Dataquest, looks at this market and includes only the revenues earned from systems operations and management services themselves. It deals with other activities such as maintenance services and help desk facilities separately. Dataquest estimates that the worldwide market for facilities management was $9·25 billion in 1991, and with a market forecast compound annual growth rate of 18·9%, this market is expected to reach $21·97 billion by 1996. The company estimates that the European market for facilities management was $899 million in 1991 and will grow at 18·4% per annum to $2 billion in 1996. In the UK, the market is estimated to have been $265 million in 1991. Notwithstanding the potential for central government IT outsourcing, this market is expected to grow to $558 million by 1996.

The Spread of Outsourcing

Specialist market researcher Yankee Group Europe estimates that the combined network management and integration markets were worth some $1·45 billion worldwide in 1989–90. By 1994–1995, various groups predict the figure will grow threefold to somewhere between $4·14 and $5·6 billion. The part of this figure coming from network management alone was some 20% in 1989–90. In 1994 to 1995, Yankee Group predicts that share will be around 33%.

Europe represents about one third of the global outsourcing market. North America has half and Japan holds the balance. The UK represents about half of the European business. The bulk of the rest is in France, Italy, Germany and the Netherlands.

There are also considerable regional and national differences in the size of internationally managed networks. The average size of networks in the US is about four times that of Japan and twice that of Europe. The prediction for market growth however is the other way around. The outsourcing market in Japan is expected to double every year with Europe growing at 50% and the US at 30% a year.

The main determinant of the size of a country's internationally managed network outsourcing market is the presence of major multinational organisations. The regulatory situation in a given country also plays a role, not because of the restrictions on network outsourcers (which are generally disappearing), but because of the dynamism encountered in a more liberal environment. Outsourcers, nevertheless, play an active role in regulation. They help to shape a regulatory environment in which users have what they would like to have rather than what they must have.

Outsourcers operate in most countries as Value Added Networks (VANs). Therefore a regulatory priority of most outsourcers is to expand the definition of a VAN. In many countries VANs are restricted to carrying data only, but this situation is quickly changing. The issue of incidental voice is likely to bring the next significant change. Already regulators in many countries have realised that it is impossible to run sophisticated data networks without voice communications. Many operators (such as Germany's Ministry of Posts and Telecommunications) are now allowing small amounts of voice to be carried over data networks. The question is then at what level is incidental voice no longer 'incidental'? Campaigning for regulatory change is a continual process of testing what regulators will allow. Outsourcers often derive new schemes of what they think should be allowed, and then work with their users to persuade regulators to allow them to do it.

Some outsourcing suppliers are expected to fall by the wayside leaving a few to dominate the market by the year 2000. The ones that survive will be those that have the ability and resources to provide the level of support required by users. Outsourcing, ultimately, is a strategic partnership in which users can concentrate on what they are good at – their core business – while network suppliers manage users' networks for them.

IT, which was once seen as strategic and providing a competitive edge, is now increasingly viewed as a utility. It is the application of IT that is becoming a more critical issue. With the increasing number of specialist companies forming credible suppliers to whom IT can be outsourced, customers have a greater choice in the types of contractual relationship they may enter into. The trend to outsource in the UK has been firm enough to be unstoppable; the point of interest for the future will be what new frontiers are forged in outsourcing innovations.

Market Dynamics and Trends

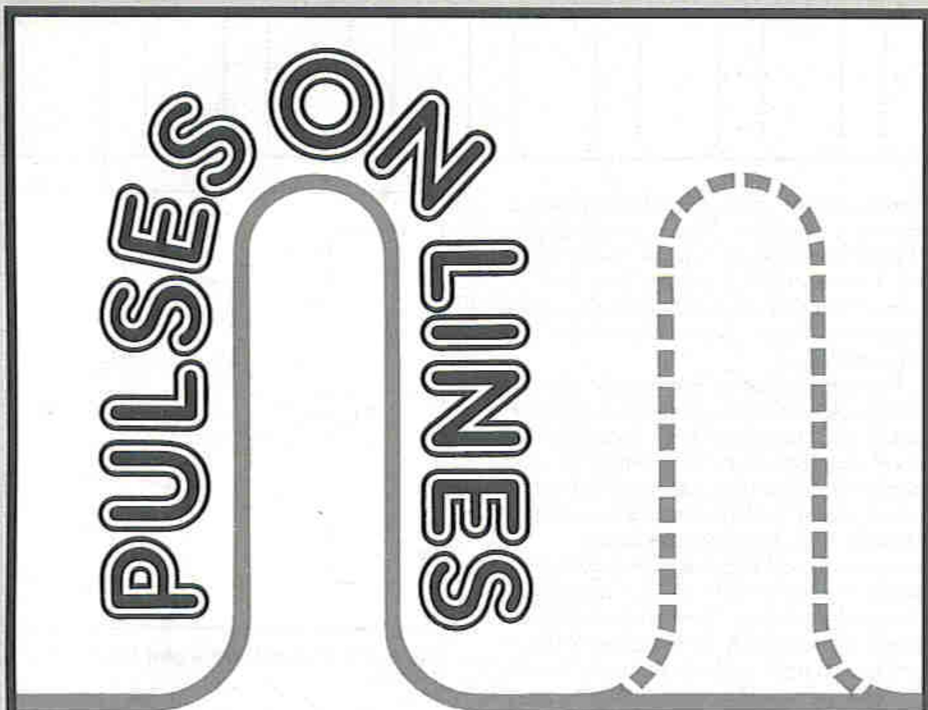
Outsourcing is probably the most discussed IT issue among the business management community. Several factors contribute to this interest:

★ **Value of management time:** In the current climate of economic difficulty and competitive pressures, organisations are sensitive to the necessity to concentrate on their core business. The skills required to manage the IT infrastructure will usually come from the management team and will take up significant portions of the collective management team's time, time that could be better spent on honing the business to meet increasing competition, i.e., the much talked-about return to core business.

★ **Resource supplement:** The rate of change of IT, coupled with the multitude of products and applications, has made it virtually impossible for individual MIS departments to maintain a sufficient level of expertise. Today, there is an industry-wide shortage of information systems experts. Due to greater career opportunities, it is easier for a facilities management company to attract and retain top information systems personnel. Facilities management firms can offer employees a dedication to state of the art systems along with the challenge and diversity of various customer sites. Furthermore, the MIS professional at a facilities management vendor does not face a dead-end career path as do many colleagues working at customer sites.

★ **Business ratios:** The trend towards using facilities management contracts as a means for transforming fixed data processing assets into variable assets is accelerating. Troubled companies in need of a cash infusion see facilities management as an opportunity to reinvest their resources for a greater return. Those not in so much financial trouble view facilities management as making good business sense. They prefer to treat information systems as a utility, much like the telephone and electricity resources, and re-deploy their assets into their core businesses.

★ **Increased choice:** Like any other market with an appearance of new participants, customers ultimately benefit from a greater choice of options for outsourcing arrangements. The range of options shown in Figure 2b is only a summary of what is currently available. As competition increases and the market matures, the choices for users will be even greater.



A Beginner's Guide

by Bryan Hart **PART TWO**

Bouncing With Energy

IN Part One we considered the electrical properties of a uniform lossless two-conductor transmission line. In this article we look at the mechanism of pulse transmission and see how it may be shown pictorially, discuss the condition for undistorted pulse transmission and consider what happens when that condition is not met.

Pulse Transmission

In Figure 8 a line is 'terminated' at $x = \ell$ by a resistor R_T. A step-pulse generator at $x = 0$ is modelled by a switch Sw, source resistor R_G and battery E. Sw is assumed 'ideal'. This means it has zero resistance between its contacts when 'on', infinite resistance when 'off', and switches from one state to the other in zero time.

Initially Sw is in position '1' and $v = 0$ everywhere along the line. At $t = 0$, Sw is switched to position '2'. As shown in Figure 9(a), the line appears to be a single resistor, R_O, as far as this signal change is concerned: the reason for this was discussed in Part One. Consequently, the equivalent circuit for calculating $v_I(0)$, the input voltage at $t = 0$, is shown in Figure 9(b). This is a potential divider circuit, so the switch change-over action causes a voltage step, v_1, to be launched onto the line.

$$v_I(0) = v_1 = \frac{ER_O}{(R_O + R_G)}$$

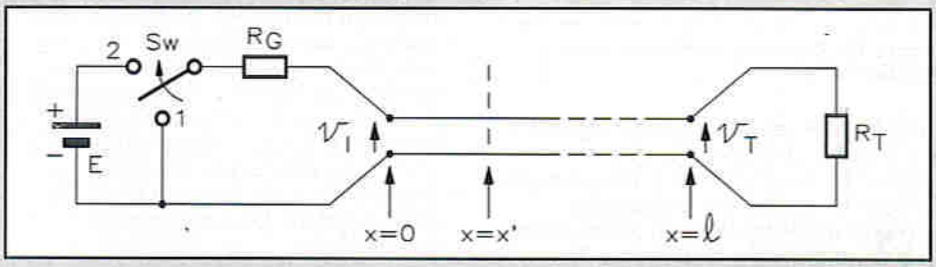


Figure 8. Line circuit for discussing pulse transmission.

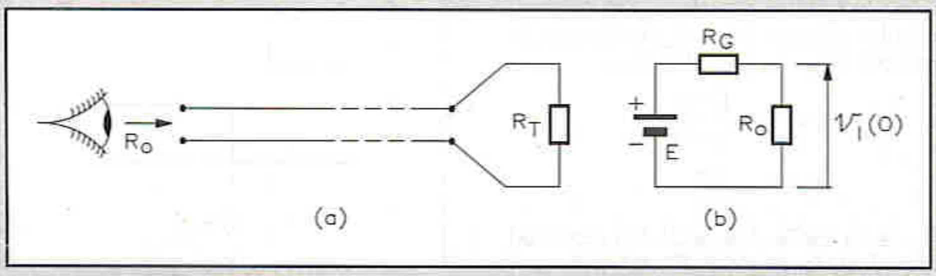


Figure 9(a). At $t = 0$ the line appears as a resistor R_O; (b). Equivalent circuit for calculating $v_I(0)$.

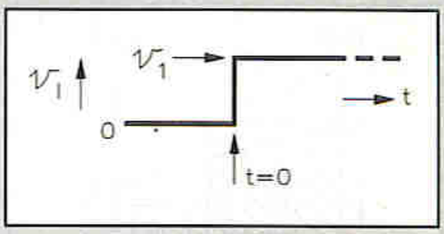


Figure 10. Resulting input waveform for Figure 9.

R_T does not figure in this expression because the step-pulse generator can have no information ('news') about it yet. Figure 10 is a plot of v_I versus t.

The progress of the step (hereon used to describe a fast-edged voltage transition) on the line can be depicted in several ways. Figure 11(a) shows v versus t at a given x (=x'), whereas Figure 11(b) gives v versus x at a given t (=t').

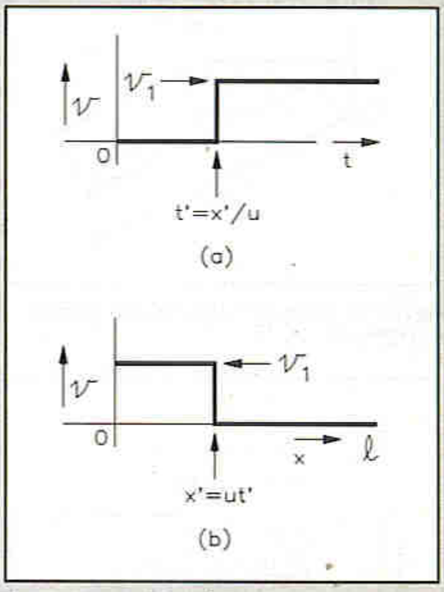


Figure 11(a). Line voltage versus time at a given x(=x'). Figure 11(b). Line voltage versus distance at a given t(=t').

More informative is the 'lattice diagram', or 'reflection chart', an initial part of which is shown in Figure 12. On this, x increases, horizontally, from left to right and t, vertically, downwards. The polarity and magnitude of the step are shown near an arrowhead on the line OP which describes the forward motion of the step for $t_d > t > 0$. The line voltage is thus $+v_1$, on OP and also in the hatched region below it, as indicated by the symbol in a box, but zero elsewhere.

Figure 12 can be regarded as a plan view of the three-dimensional plot of the variables v, x, t. An isometric view is given in Figure 13. A cross-section of the resulting solid, on a plane at $x = x'$ produces Figure 11(a) and a cross-section at $t = t'$ generates Figure 11(b). As Figure 12, suitably interpreted, contains all the information of Figure 13; we will use the more-easily-drawn lattice plot.

In the special case $R_T = R_O$, the line is said to be 'matched' or 'correctly-terminated' at $x = \ell$. Electrically, there is no discontinuity at $x = \ell$: the line appears, as infinitely long to

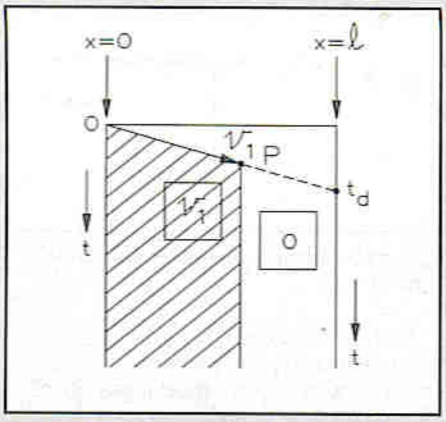


Figure 12. Showing the start of a 'lattice diagram'.

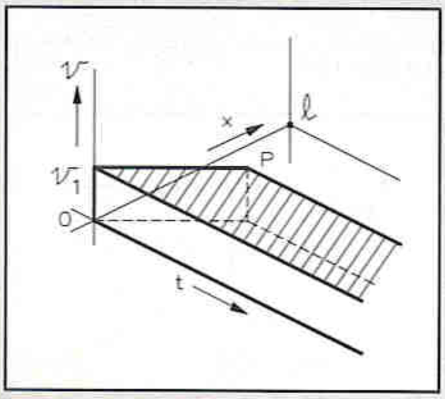


Figure 13. Three dimensional plot related to Figure 12.

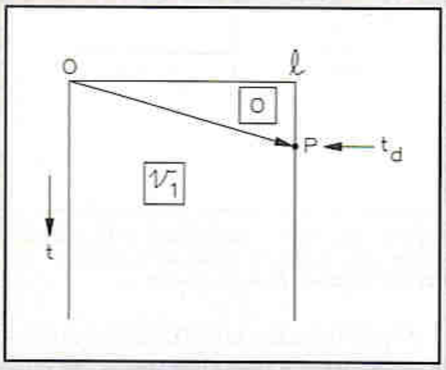


Figure 14. Lattice plot for Figure 8, for $R_T=R_O$.

the source. Physically, energy is dissipated in R_T at the same rate as it is supplied to the line at x = 0, so there is a one-way transfer of energy from source to load.

v_T is a replica of v_I delayed by an interval t_d so Figure 9(b) is valid for all values of t. The diagonal OP of Figure 14 comprises the complete lattice plot. The hatching shown in Figure 12 for the region occupied by v_1 is omitted here, and from now on, for ease of drawing.

Reflections

For the general case $R_T \neq R_O$, the line is incorrectly terminated at $x = \ell$. There is a difference between the rate at which energy reaches R_T from the source and the rate at which it is dissipated in the resistor. A balance is now established by the phenomenon of 'reflection', which involves a two-way energy flow. Thus, a voltage step is reflected back from R_T towards the sending end. This may differ in polarity from the incident step and differs in amplitude, except in two special cases, but travels with the same velocity, *u*.

This aspect of signal transmission along a line is often overlooked, and can cause all sorts of unexpected problems, especially in critical situations where for example RF counters or digital data inputs are fed via coaxial cables, and the terminal impedance is mismatched. Reflections are also a common physical occurrence in engineering science, e.g., when light strikes a partially-silvered glass surface. They arise whenever there is a discontinuity in the nature of the transmission path, and are the basis of many types of echo-sounding equipment design. Apart from radar, examples include ultrasonic detectors for the location of flaws within the body of a metal, and for the location of shoals of fish in the sea.

Designating the reflected step v_2, we define a voltage reflection coefficient ρ (the Greek alphabet symbol *rho*, corresponding to the letter r). Adding a subscript $_T$ to refer to R_T, analysis reveals:

$$\rho_T = \frac{v_2}{v_1} = \frac{(a-1)}{(a+1)}$$

$$\text{in which } a = \frac{R_T}{R_O}$$

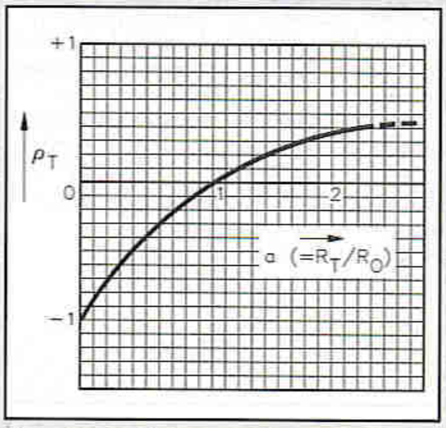


Figure 15. Reflection coefficient, ρ_T, as a function of 'a'.

A sketch of ρ_T versus a is given in Figure 15. It is a section of a hyperbola. At a = 1, the slope of the curve is 0·5, so a 10% mismatch between R_T and R_O, due to tolerances, produces a reflected step with an amplitude only 5% of that of the incident step. As v_1 travels back along the line it adds, algebraically, to the voltage *already existing* on the line. When it reaches x = 0, there is a further reflection if $R_G \neq R_O$. In this case the reflected step, v_3 is related to v_2 by:

$$\rho_G = \frac{v_3}{v_2} = \frac{(b-1)}{(b+1)}$$

$$\text{where } b = \frac{R_G}{R_O}$$

Figure 15 applies if ρ_G and b are substituted respectively for ρ_T and a. The reflections continue, as shown in the lattice sketch of

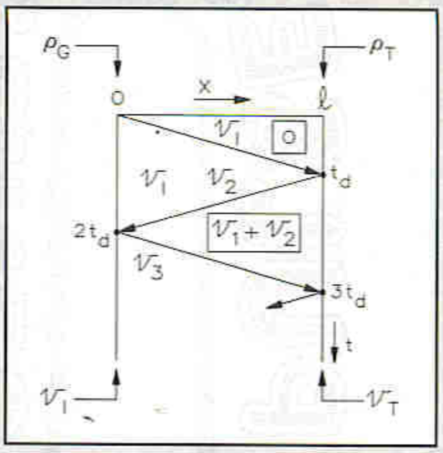


Figure 16. General lattice plot for $R_T \neq R_O$, $R_G \neq R_O$.

Figure 16. The 'final' values of v_I and v_T only occur, theoretically, after an infinite time. Then:

$$v_I(\infty) = v_T(\infty) = \frac{ER_T}{(R_T + R_G)}$$

This is the potential difference that applies for a line of zero length.

The path of a ball on a billiard table provides a graphic analogy for a lattice plot. Struck by a cue, in a diagonal direction from the vicinity of a corner pocket, the ball bounces off the opposite cushion and continues to bounce off opposite cushions in its zig-zag journey.

The usual problem is to determine v_I and v_T as a function of time. This information can be obtained from a suitably marked-up lattice plot. The following three examples, which are relevant to commonly occurring practical situations, illustrate this. All three cases use the set up of Figure 8, with R_O = 50Ω and t_d = 17·5ns.

Example 1. Parallel match at $x = \ell$.

$E = 2V$; $R_T = R_O = 50\Omega$; $R_G = 50\Omega$
Therefore $v_I = 1V$; $\rho_T = 0$.

The lattice plot is Figure 14. Referring to the billiard ball analogy, the ball drops into a centre pocket on the opposite side of the table after being struck. Ideal waveforms are shown in Figure 17. The experimentally observed waveforms (Figure 18) differ in two respects. Firstly, v_T has a finite rise time which is the same as that of the pulse-edge generator. Secondly, there is a small 'blip' on the waveform for v_I, whose origin is discussed later.

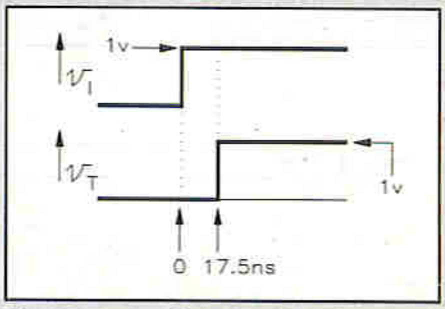


Figure 17. v_I, v_T for Example 1 of text.

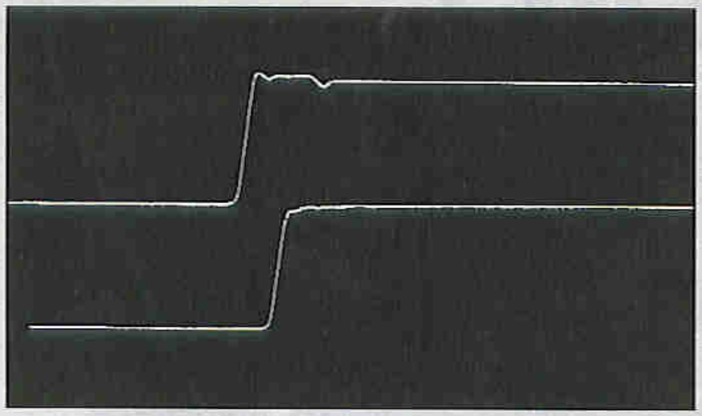


Figure 18. Observed waveforms for Example 1. Upper trace v_I, lower trace v_T. Common vertical scale: 0·5V per major division. Common horizontal scale: 25ns per major division.

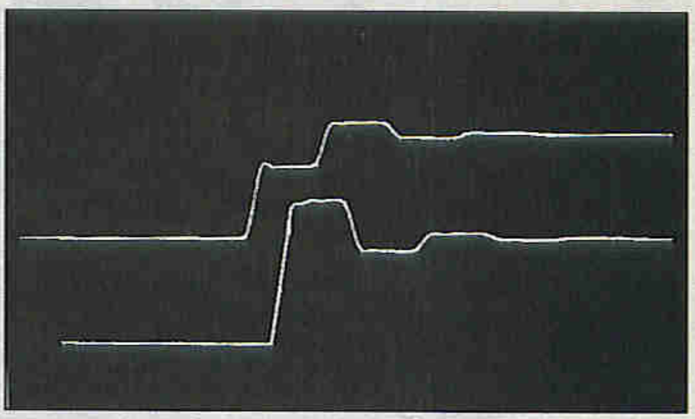


Figure 23. Observed waveforms for Example 3. Scales as in Figure 18.

Example 2. Series-matching at x = 0

E = 2V; $R_G = R_O = 50\Omega$; $R_T = \infty$ (i.e. open circuit)
Therefore v_I = 1V; $\rho_T = +1$; $\rho_G = 0$.

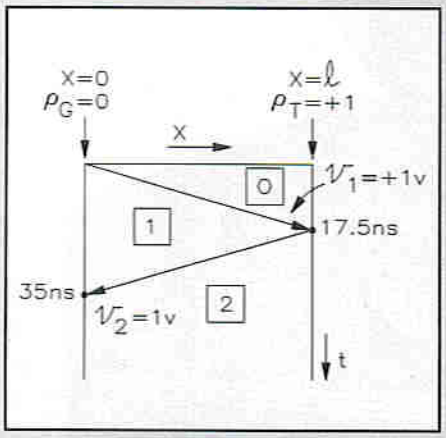


Figure 19. Lattice plot for Example 2.

The lattice plot is Figure 19. Figure 20 shows v_I, v_T. In the billiard ball analogy the ball now falls into a pocket on the same side of the table as it was struck, after bouncing once off the opposite cushion. Note, in passing, that there was also series matching at x = 0 in Example 1. However, that was incidental and had no effect on waveform shape, only waveform amplitude.

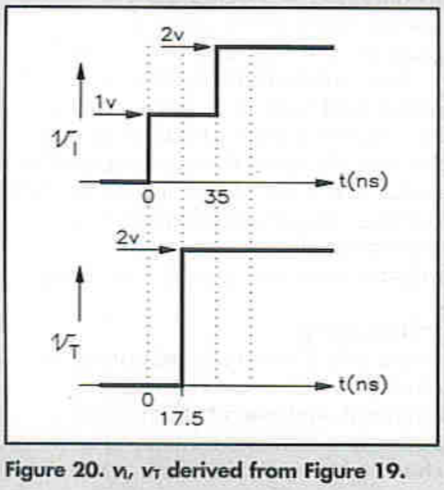


Figure 20. v_I, v_T derived from Figure 19.

Example 3. Incorrect termination at x = 0, x = ℓ

E = 1V; $R_G = 25\Omega$; $R_T = \infty$
Therefore $v_1 = {}^2\!/_3$; $\rho_T = +1$; $\rho_G = -{}^1\!/_3$

Figure 21 is the lattice plot. Ideal waveforms are shown in Figure 22 and, for comparison, experimental waveforms in Figure 23. The alternate overshoots and undershoots in v_T produce an effect that is similar to the 'ringing' that can be obtained when a voltage step is applied to a series circuit comprising an inductor, a resistor and a capacitor.

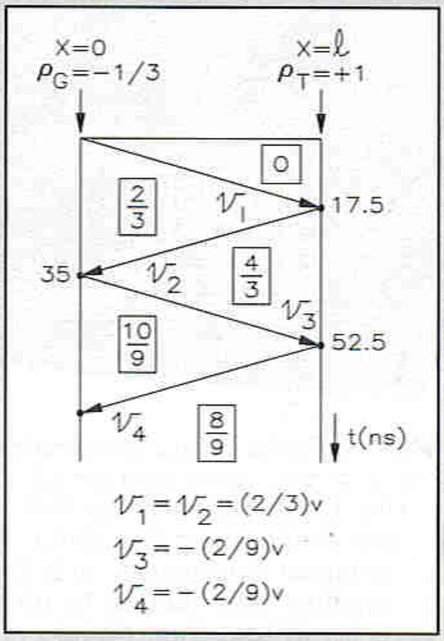


Figure 21. Lattice plot for Example 2.

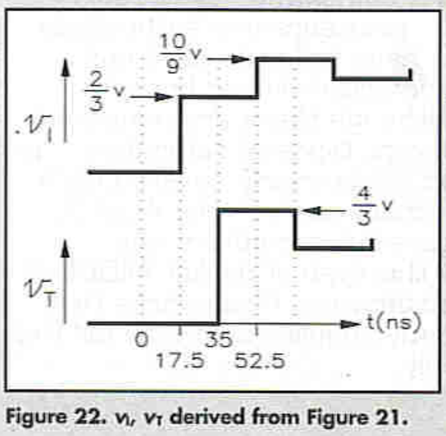


Figure 22. v_I, v_T derived from Figure 21.

Blips

Lead inductance and shunt capacitance are parasitic elements that cannot be avoided where fixed resistors are used to terminate a line. These elements can give rise to unwanted spikes or 'blips' on the waveforms. The mechanism responsible for producing these is as follows. Referring to Figure 8, $R_G = R_O$ but $R_T(=R_O)$ is effectively shunted by a small capacitance, and the input capacitance of the oscilloscope probe used to observe v_T. When a perfect step is applied to the line this causes the termination to appear, momentarily, as a short circuit, so a *negative* spike is reflected back to x = 0, where it is absorbed (see Figure 24(a)). for an input 'edge' having an finite rise time, the spike amplitude is diminished as indicated in Figure 24(b).

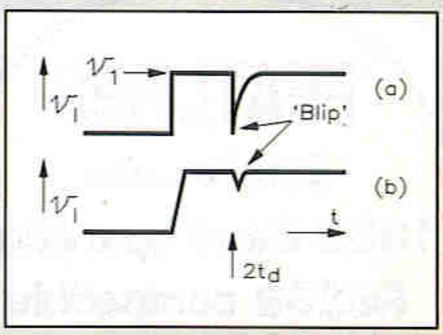


Figure 24(a). Blip for amplitude is ½ for perfect step input; (b). Blip amplitude diminishes for a finite rise time input.

If the leads of R_T are long and the oscilloscope probe is removed, lead inductance dominates and gives rise to a blip of opposite polarity to that in Figure 24(b). In high-speed pulse work (e.g., nuclear pulse instrumentation), where the preservation of pulse shape is important, blips are minimized by the use of specially manufactured terminating resistors.

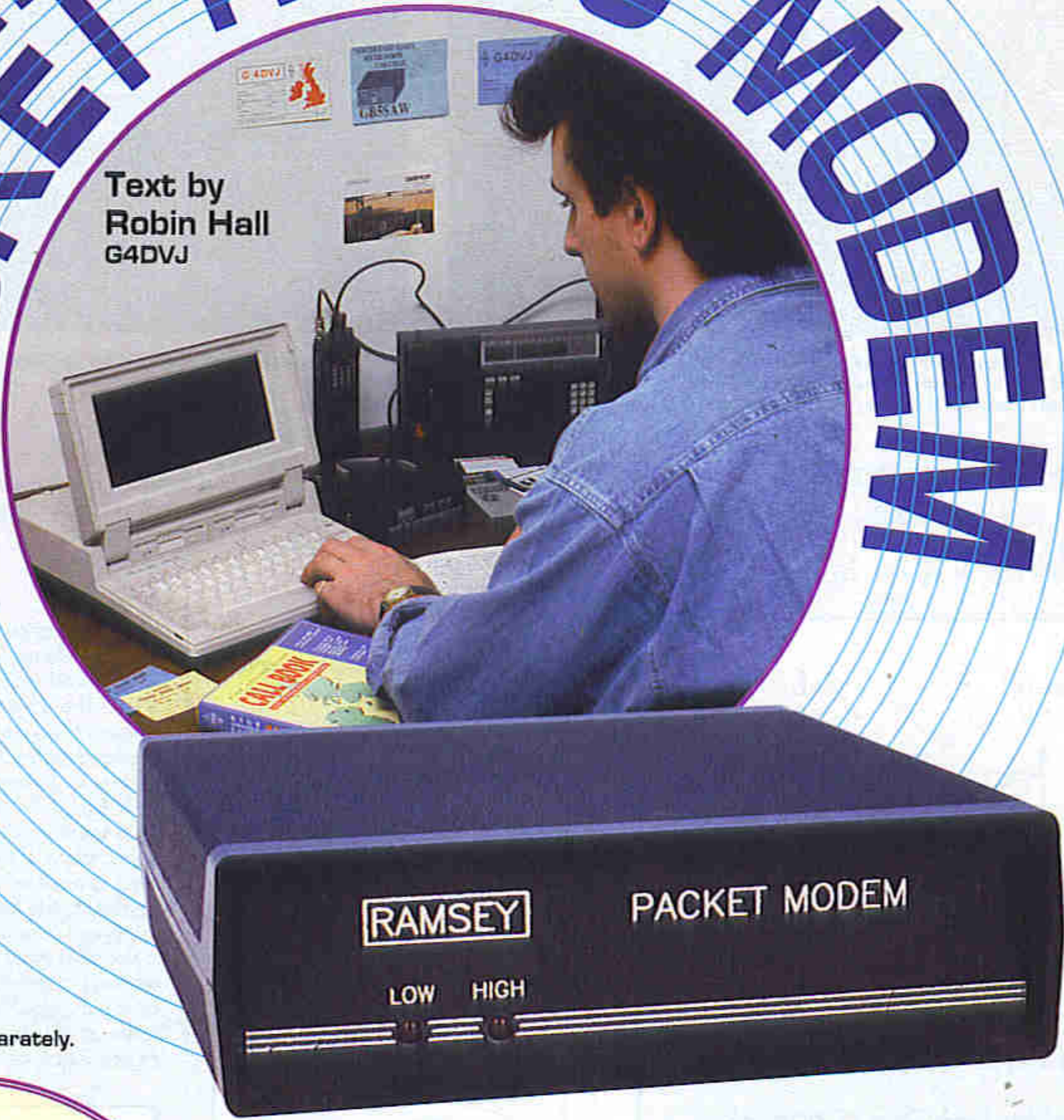
Part Three of this series concludes by discussing some system implications of transmission line interconnections.

2
PROJECT RATING

KIT AVAILABLE
CP36P
Price £59.95 AO

PACKET RADIO MODEM

Text by
Robin Hall
G4DVJ



Please note the case shown is not included in the kit and must be purchased separately.

FEATURES
Easy to use
1200 Baud operation
RS232 compatible
Powered from computer

Packet Radio is fast becoming one of the more popular of the 'Data' type modes that are available for the radio amateur enthusiast, and it enables two hobbies to be enjoyed together, namely that of amateur radio and computing. Most radio amateurs and enthusiasts have today at least one computer in the home. Although there are numerous different types of computers the IBM PC/AT is mainly covered here, although others such as the Atari ST and Commodore 64 computers can operate with this type of packet MODEM with suitable software. Please note that Maplin currently supplies software for the IBM PC/AT only.

There are two types of MODEM ICs available for use in packet radio, and the one selected for this particular type of circuit is the Texas Instruments TCM3105. Although this device was originally designed for telephone MODEM use, the frequencies are compatible with the packet radio tones used at 1200 baud on the VHF and UHF bands.

The Packet Radio MODEM presented here is ideally suited for the enthusiast starting off and wanting to learn more about packet radio, and the radio amateur already using an expensive terminal node controller (TNC), who might like to monitor another packet frequency.

History

There are a several communication modes available for the radio amateur, and each has their own distinctive characteristics. One of the original machine-sent modes

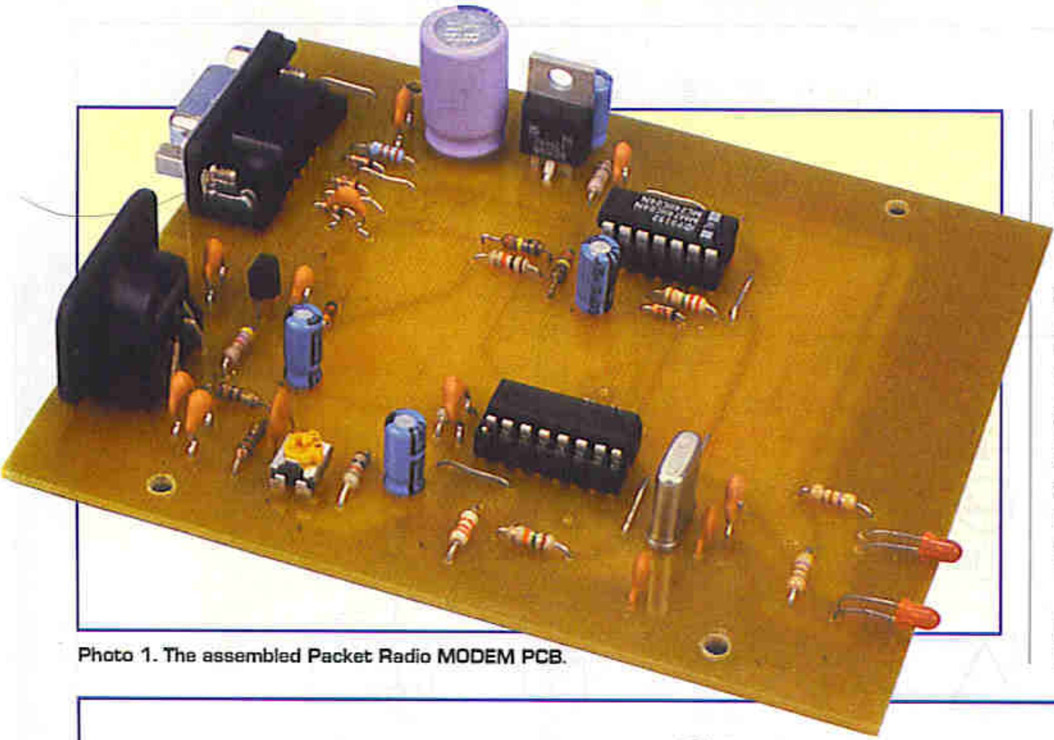


Photo 1. The assembled Packet Radio MODEM PCB.

other stations, even right round the world. Also by getting long distance (DX) station information from DX Clusters, and generally sending files from one computer to another.

Originally, the main line route to packet radio was through a packet radio controller unit called a terminal node controller (TNC). Such units were developed in Tucson, Arizona and known as the TAPR TNC. They have a microprocessor built in, such as a 6809 or Z80, and an EPROM that contains the program to control operation of the TNC; the computer in this case acts as a 'dumb terminal'.

The other method, developed by Digicom for the Commodore C64, used a MODEM IC to encode/decode

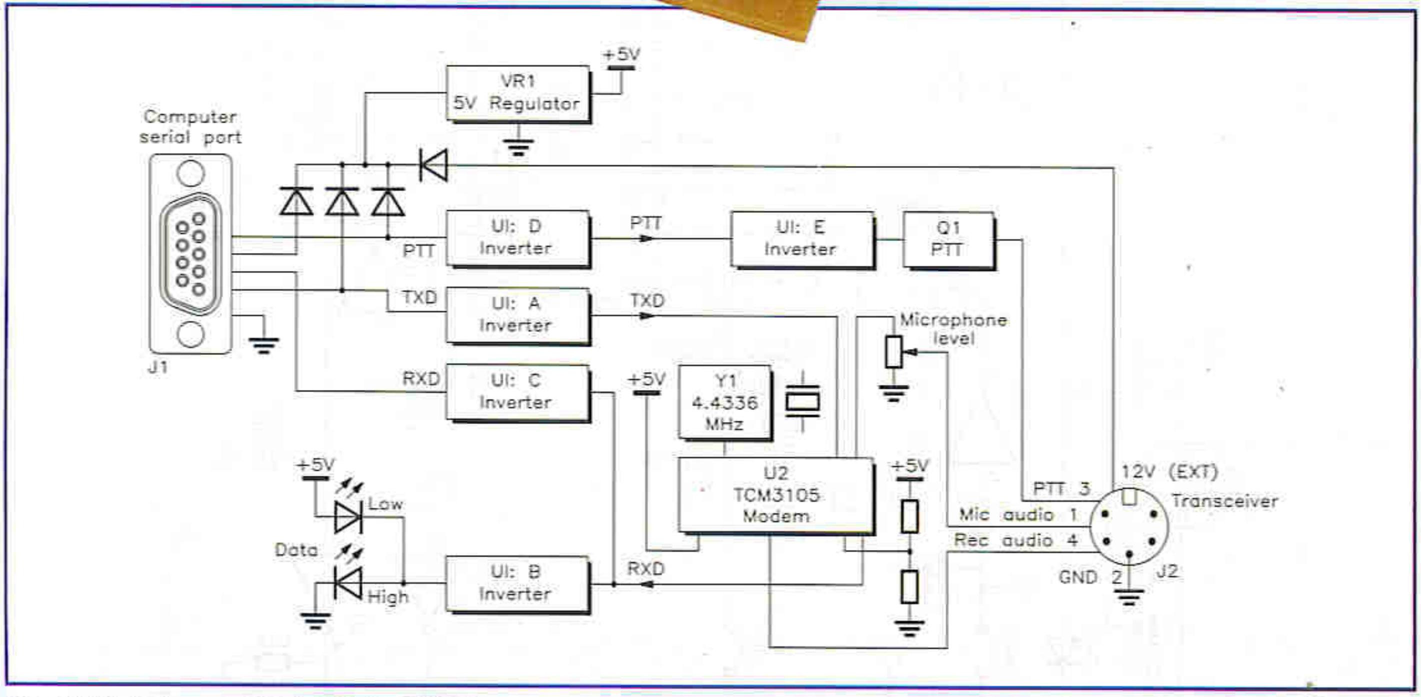


Figure 1. Block diagram of Packet Radio MODEM.

was Radio Teletype (RTTY for short) and a few years ago messages were sent on the air using teleprinters and terminal units. These were connected to the transmitter/ receiver via a MODEM and contacts were made on the various bands. RTTY is still used today but unfortunately less and less so.

As radio electronics became more sophisticated so the old teleprinters were changed for electronic terminals and then fully-fledged computers. With the limitations of the codes used for RTTY and the speed at which data could be sent, new forms were developed. Just as TTY started on the telephone network and subsequently adapted for radio, so packet data in the form known as X.25 was used on networks, modified for amateur radio and designated AX.25. There are other forms of packet radio, adapted originally from computer networks such as TCP/IP, and these can also be found on the VHF and UHF frequencies.

There are a number of things that distinguish packet radio from other modes, not least that a large number of stations can use the same frequency and pass information to individual stations, either directly or via bulletin boards (BBS). Packet radio does not handle data in the same way as RTTY and newcomers might get confused when in contact with other stations – thinking that the link may have locked up, then all of a sudden unexpectedly receiving a mass of information. Packet radio is used on the high-frequency (HF) bands, where the speed is 300 baud, and on the VHF/UHF bands, where the speed is 1200 baud. There are major uses for packet, for instance by getting information off BBS and to send and receive messages via

the correct tones and a computer program to replace the TNC and handle the AX.25 protocol. At this point the development split and in Germany a group of radio amateurs formed BayCom. In essence, BayCom used the same MODEM IC technology, designed MODEM hardware and wrote a program for the IBM PC/AT utilising the computer's serial port to interface with the MODEM – thus emulating the TNC and terminal. In America, fired by the Digicom system, amateurs there produced Poor Mans Packet, the hardware (which used the same MODEM IC) was designed for use with the IBM PC/AT, but interfaced through the parallel port instead of the serial port.

Another mode for use with TNCs is known as 'Kiss mode'. Interestingly enough it means that a TNC can be converted so that it can be directly

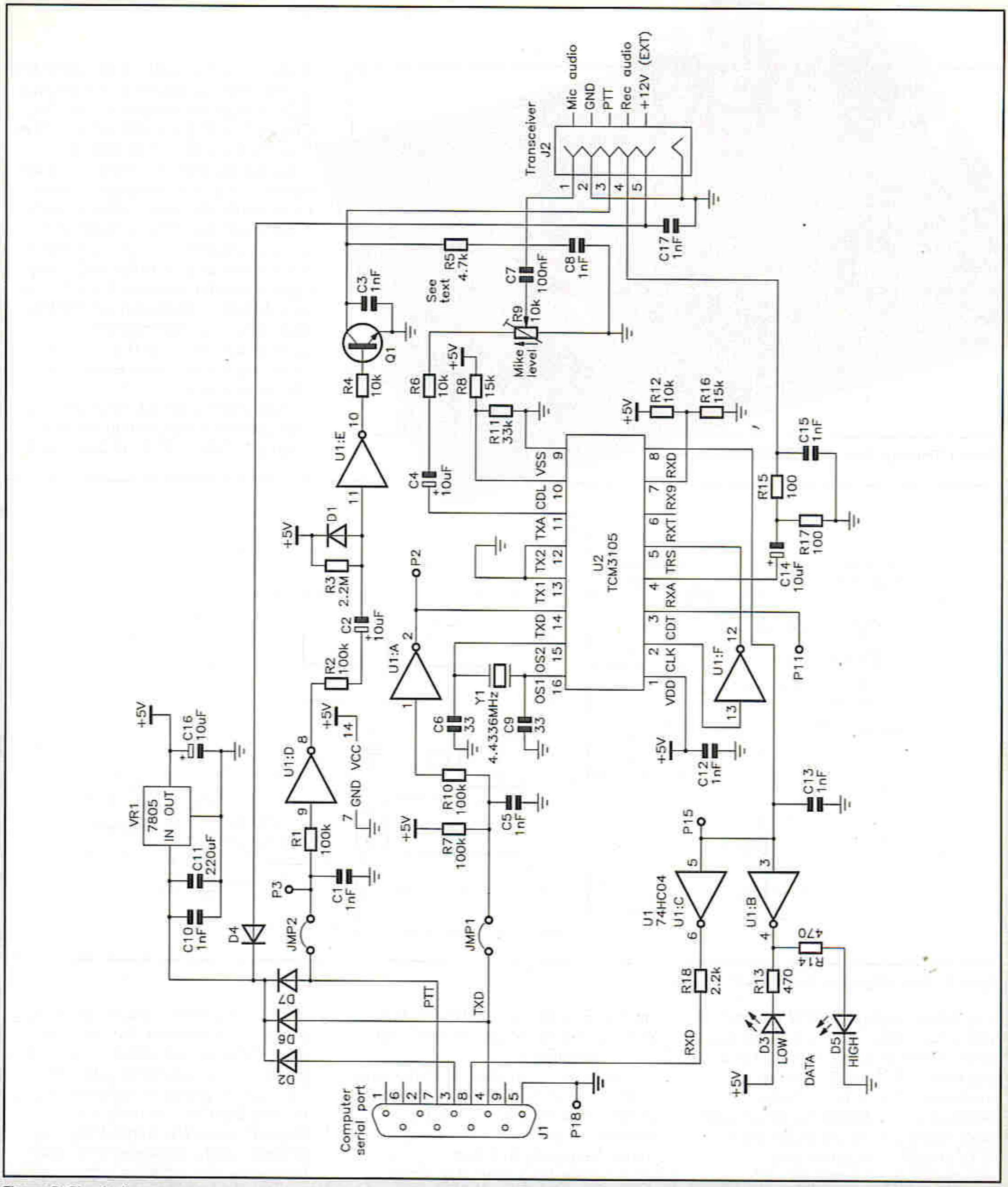


Figure 2. Circuit diagram.

driven by some of the Packet MODEM programs, in conjunction with a linking program such as (TFPCR). This means, paradoxically, the TNC is behaving just as if it were only a packet MODEM! So it is impossible to tell, for instance, whether someone is using a TNC such as the TINY-2 Mk1 or an MFJ 1278 in 'Kiss mode' using TFPCR and Eskay Packet SP (often referred to as Sigi's Packet or just SP); or a Packet MODEM using TFPCX and SP – even the screens on their respective computers would be the same. Some of the other programs such as Graphic Packet also have the ability, to control a TNC or Packet MODEM.

Circuit Description

Referring to Figure 1, which shows the block diagram for the Packet MODEM, and Figure 2, the circuit diagram, circuit operation is as follows:–

As the power requirements for the unit are not particularly great, the supply is obtained from the RS232 port on the host computer. There are three diodes, D2, D6 and D7 and these are connected to various active RS232 lines, and these steer the positive going signals to the reservoir capacitor, C11, and a +5V DC regulator (7805), VR1. This 'phantom' supply can be supplemented by connecting an external supply of +12V DC on pin 5 (+12V) and pin 2 (0V) of the DIN socket J2. In practice it has been found that most computer

RS232 lines are adequate to supply the required voltage. However, if problems are experienced try using an external supply.

On reception of suitable packet signals from a frequency modulated (FM) receiver or transceiver (VHF/2m or UHF/70cm), audio from the loudspeaker output is fed into the Packet MODEM on pins 4 (received audio) and 2 (0V) of the 5-pin DIN socket, J2. This passes via a RC network to pin 4 of U2 the TMC3105, the signal is then converted to a suitable digital data signal by the IC. This data signal is inverted and buffered by U1:B, and U1:C, a 74HC04 Hex Inverter. The output from U1:B drives two light emitting diodes (LEDs), D3 and D5, via current limiting resistors, R13 and R14. D3 is connected to +5V DC and D4 is connected to the 0V rail. These indicate the logic levels of data signal, represented by the tones of the incoming audio signal, as they are received and should flash alternately. These LEDs give an indication whether the unit is working or not – if there are no signals being received, only one LED will be illuminated. The output from U1:C is fed to the computer on pin 8 of the 9-way D-type RS232 port connector J1.

On transmission, the RS232 level data signal (±12V) is brought into the Packet MODEM on pin 4 of the 9-way D-type RS232 port connector J1. The data signals are converted to TTL level (+5V/0V) by U1:A and are introduced to U2 TCM3105 on pin 15. U2 has been set up to convert the data to BELL 202 tones, (1200Hz and 2200Hz). The precise clock frequency required by the TCM3105 is supplied by Y1, a 4·4336MHz crystal. The audio tones, corresponding to the logic levels of the data signal, are then brought out via C4 and R6 and to a 10k preset potentiometer. This preset allows the correct signal level for the microphone input of the transceiver to be set. The audio signal is output on pin 1 of the 5-pin DIN socket, J2. The keying (PTT) signal from the computer, which is introduced on pin 7 of J1 on the 9-pin D-type connector passes to U1:D which converts the keying signal to TTL level. The output from U1:D is connected to a monostable comprising R2, C2, R3 and U1:E. The purpose of the monostable is to prevent the transceiver being permanently switched to 'transmit' should the computer 'crash'. The output from U1:E controls Q1, a 2N3904 NPN transistor. The collector of Q1 is used to operate the PTT line of the transceiver and is connected to pin 3 of the 5-pin DIN

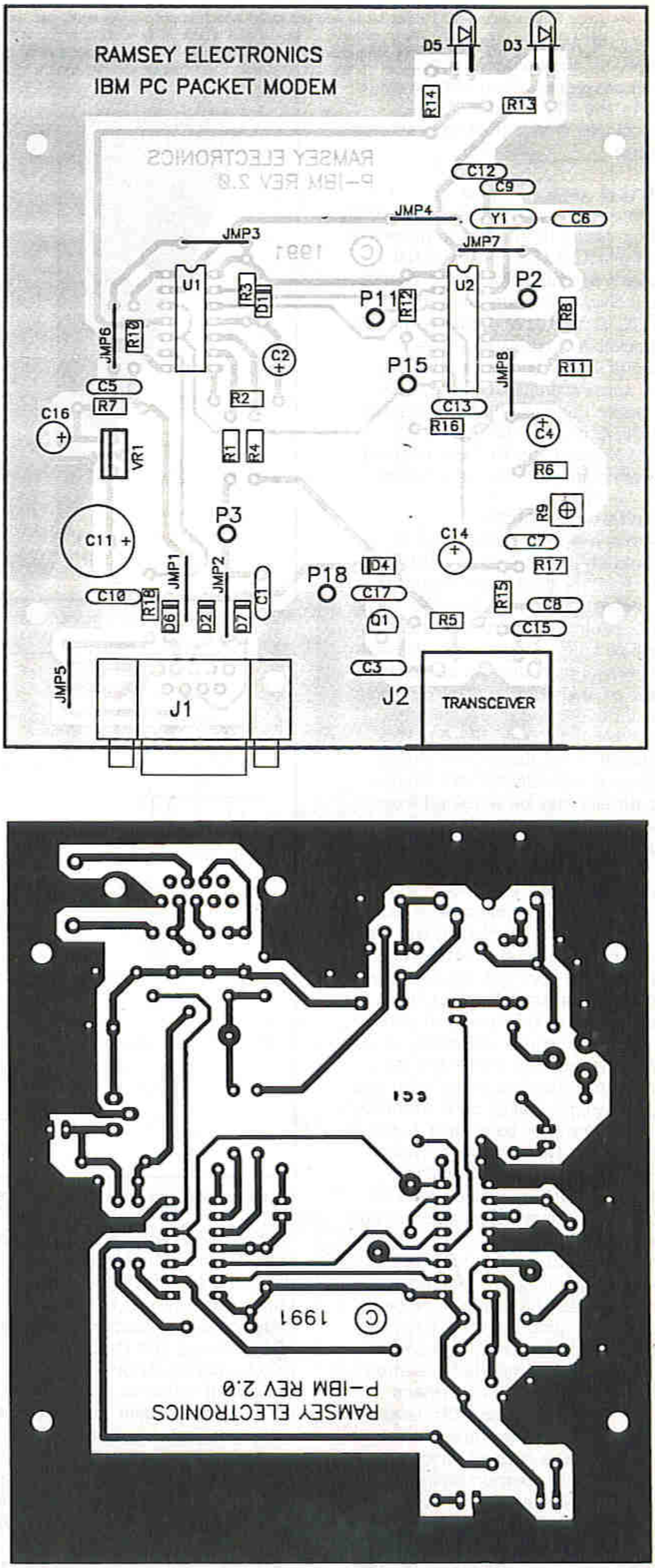


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Figure 3. PCB legend and track.

socket J2. When transistor Q1 is biased on, the collector drops to earth potential, which effectively shorts the PTT line and the transceiver is switched to transmit (keyed).

Hints and Tips

There are several suggestions worth noting. Using IC sockets is generally good practice but not essential. Sockets are not provided in the kit, and if they are to be used, one 14-pin DIL IC socket and one 16-pin DIL IC socket are required – see Optional Parts List. It is possible that some transceivers may 'key up' when connected to the Packet MODEM, this will be due to R5 (4k7) keeping the PTT line enabled. In such cases R5 can be omitted.

Construction

There are two possible ways of constructing the Packet MODEM. The usual method is to construct it so that it can be used on the serial RS232 port as described, but it is possible to modify the connections for parallel port operation. For this mode of operation another program would have to be used, such as 'Poor Mans Packet' (PMP). This program is not supplied in the kit, neither is it available from Maplin, but details may be obtained from the address given at the end of this article.

The kit includes the PCB, the legend and track are shown in Figure 3, and all the components required to build the unit, excluding the case which is available separately. It is a good idea to sort out and identify the components before soldering them in place. This way one gets to know the values and check to see if any are missing. There are very good instructions supplied with the kit, showing a logical path to follow.

If you are new to project building, refer to the Constructors' Guide (order separately as XH79L) for helpful practical advice on how to solder, component identification and the like.

It is best to start by fitting and soldering the larger components first, such as the sockets. Note that this is contrary to our normal recommendation and is based on Ramsey's recommended assembly sequence and check list. Photo 1, shows the assembled PCB. Start by fitting the connectors J1 and J2. Next fit the crystal, which should be soldered in position as indicated. Identify the ICs and solder them in position, or if sockets are being used, solder these in place instead, making sure that the notch at the top is correctly orientated on the board. Fit the regulator taking care

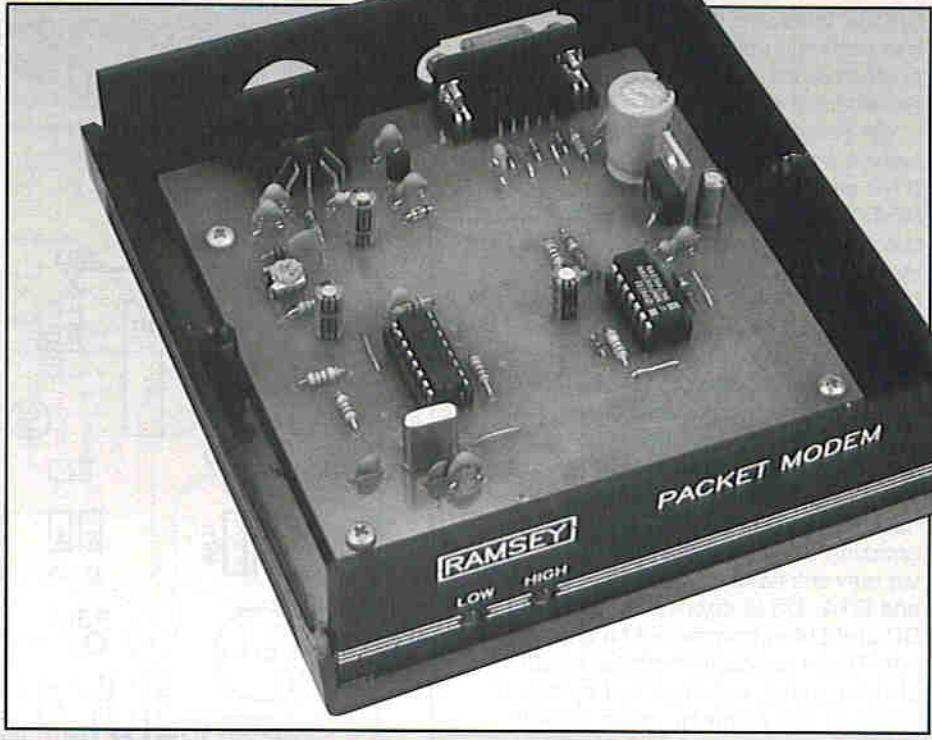


Photo 2. The assembled Packet Radio MODEM PCB in box.

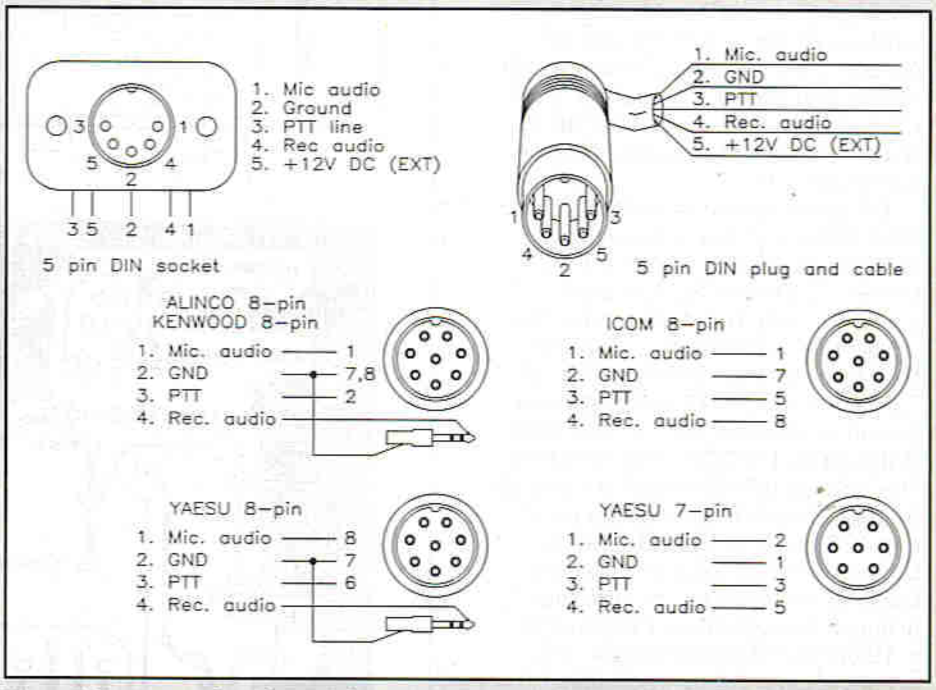


Figure 4. Some examples of connections to common transceivers.

that it is correctly positioned on the PCB. Next fit the transistor again correctly orientating it on the board. Identify and fit the capacitors, the electrolytic types are polarised and these should also be correctly orientated on the board, refer to the legend. Next, fit the preset potentiometer making sure that all three leads are soldered. Fit the resistors, preshaping the leads before fitting and soldering them in place. The light emitting diodes (LEDs) should stand off the PCB and angled forward. Identify the diodes and fit these on the board making sure that they are orientated correctly.

Finally, with wire offcuts, shape and solder in the jumpers (omitted for parallel port operation), the positions of which are identified on the PCB legend.

The completed board should be checked; ensure that the components have been fitted correctly, and that there are no solder bridges or untrimmed wires standing proud of the PCB.

To finish off, there is a pre-drilled case available for the kit (CP37S), which includes feet and fixing screws. It is quite easy to fit the PCB into the case (see Photo 2) as there is no measuring filing or drilling to do! There are also a number of

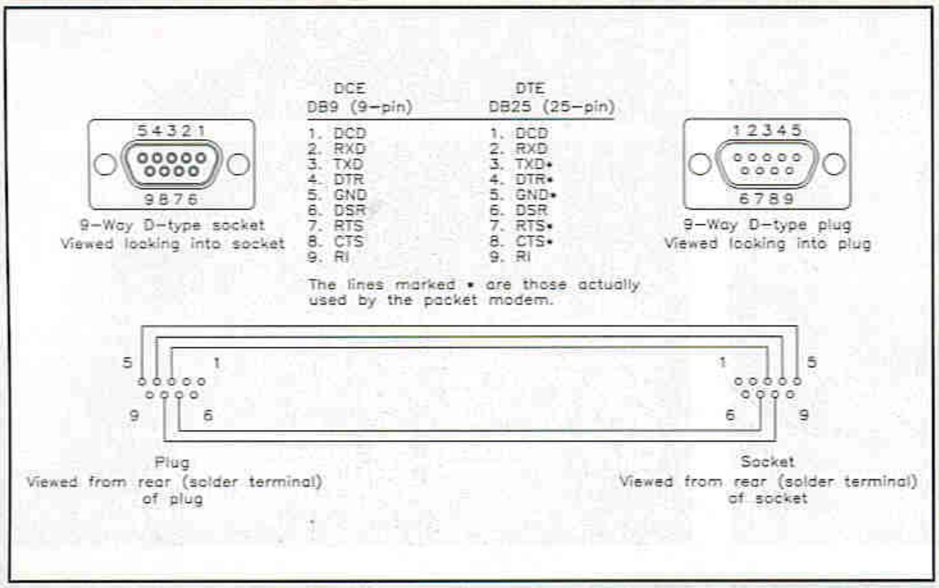


Figure 5a. RS232 9-way to 9-way cable and connections.

boxes available from Maplin that would make a suitable enclosure, although some drilling would be required.

Connecting Leads

The leads required for the Packet MODEM are a patch lead to connect the MODEM to the transceiver and an RS232 serial cable.

Ready-made patch leads are available for various transceivers and adopt the common 5-pin DIN connection that most Packet MODEMs and TNCs use. If a radio patch lead is not obtainable then a correctly terminated patch lead for your individual transceiver or receiver will have to be made up. Figure 4 gives some examples of the common types, and the Optional Parts List gives suggested components.

The RS232 connector found on most IBM PC/ATs is normally one of two types, either 25-way or 9-way D-type plug. Whereas 25-way RS232 cables are readily available, 9-way RS232 cables do not seem to be. Generally most 9-way extension cables are intended for CGA video applications and some important pins required by the Packet MODEM are not connected. In many cases a lead will have to be made up, the connections are 'straight through' and not 'reversed'. For a 9-way to 9-way cable, simply link pins with the same numbers, see Figure 5a.

For a 9-way to 25-way cable the corresponding pins should be linked, see Figure 5b. Only pins marked with an asterisk are used by the Packet MODEM. Suggested components have been included in the Optional Parts List.

Setting Up

Setting up the Packet MODEM is fairly straightforward and can be achieved without any test equipment. The only adjustment that needs to be made is setting the audio output level (microphone input level) by adjusting preset R9. Generally, start with R9 at its mid-travel position. The final setting is a matter of trial and error – the correct setting is the lowest one that achieves the best connection with the least number of broken connections or errors.

There is a multitude of possible programs to run the Packet MODEM, and it is essential to follow the instructions in the Help or Readme files and from within the programs. A good entry level program is BayCom Version 1·2, which is included in the kit.

Rear panel of the Packet Radio MODEM showing the 9-way D-type and the 5-pin DIN connectors.

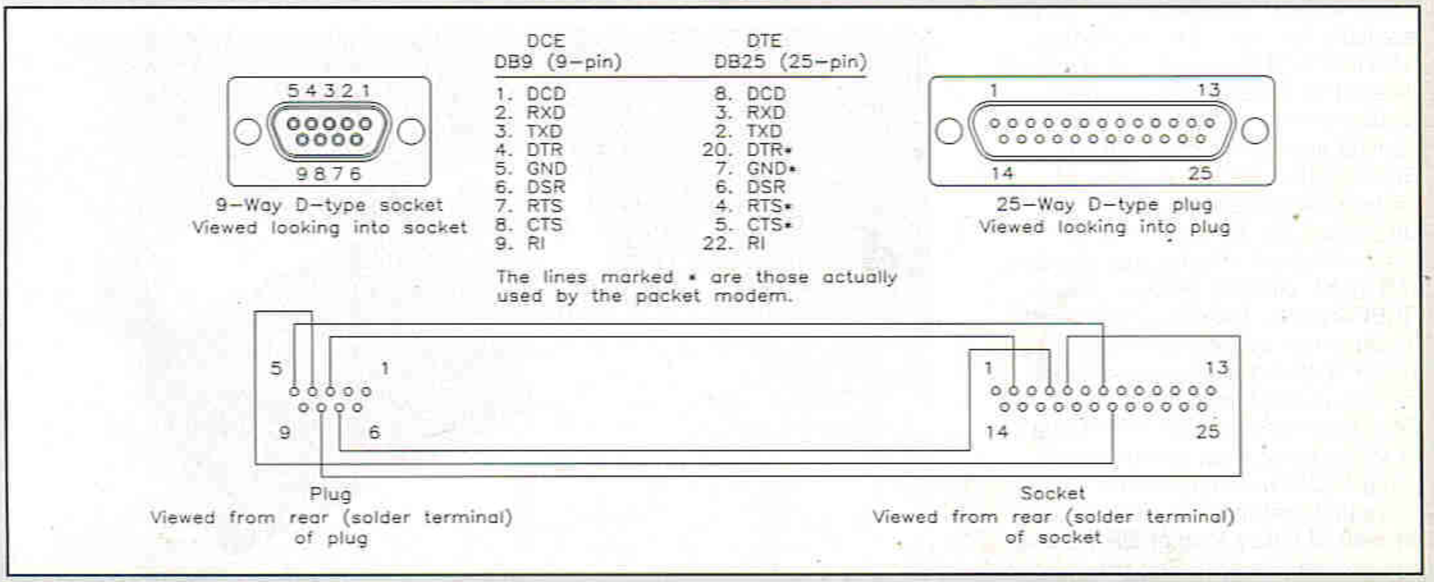


Figure 5b. RS232 9-way to 25-way cable and connections.

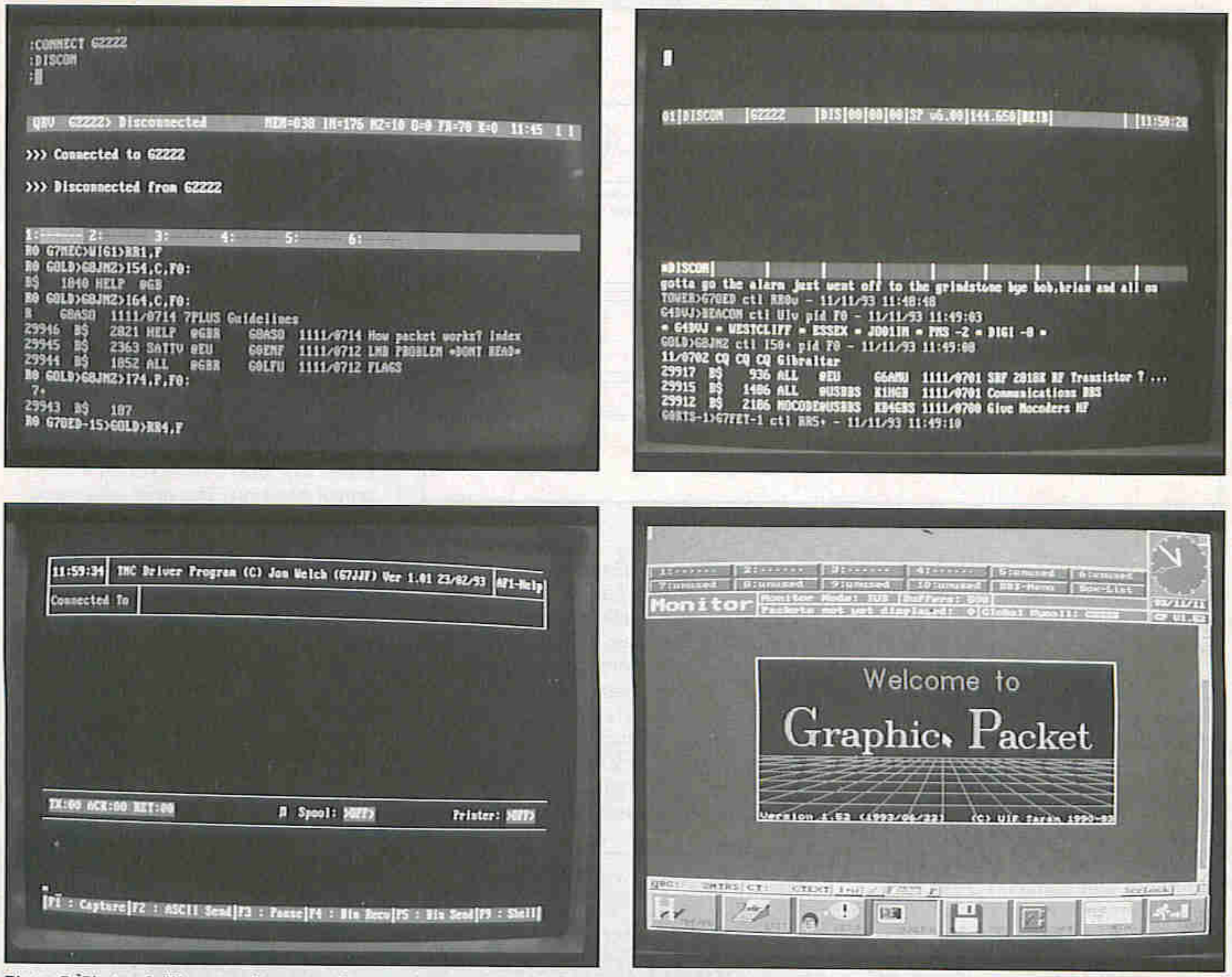


Photo 3. Shots of different software packages on screen: (top left) BayCom. ©Copyright 1992, Florian Radlerr, DL8MBT, All Rights Reserved. (top right) Eskay Packet SP. ©Copyright 1989-1994, S. Kluger, All Rights Reserved. (above left) Multi-User BayCom. ©Copyright 1994, J. Welch G7JJF, All Rights Reserved. (above right) Graphic Packet. ©Copyright 1994, Ulf Saren DH1DAE, All Rights Reserved.

Once everything has been set up with the leads connected, and the program running, set the transceiver or receiver to a suitable frequency. Packet information should become visible on the screen along with the LEDs flashing on the Packet MODEM 'in tune' with the data.

Other Software

There are other programs that are available for use with the Packet MODEM and these can be obtained direct from the original authors, from shareware libraries, bulletin boards and Compact Disc Data Storage (CD-ROM). At time of writing compatible programs are BayCom 1·5a, Eskay Packet SP (Sigi's Packet), Multi-User BayCom (MUBAY), Graphic Packet, and G8BPQ Node. Examples of screen displays can be seen in Photo 3. There is also a program available for the parallel port version called Poor Man's Packet (PMP). Most of these have been compressed using PKZIP and need to be 'unzipped' before use. There is a version of Eskay Packet SP that will run on the Atari ST. For the Commodore C64 there is of course the Digicom software (complete with interface).

It should be noted though that the cost of obtaining titles from one of these methods only covers the price of the disks. Under the terms of Shareware licensing if the programs are used on a regular basis then a registration fee/donation needs be sent to the original author unless the licence grants exemptions and the exemptions are satisfied. Details of licensing and registration fees will be found in the documentation supplied with the software. In return for registration, details of software upgrades, help, additional documentation, etc., may be provided; the nature and extent of such will depend on the supplier.

The Packet Radio MODEM kit and software as supplied.

Additional Information

There are packet radio groups and clubs in most areas, such as KEPAC and the Essex Packet Group. There is also the British Amateur Radio Teledata Group (BARTG) which caters for most electronic data modes including Packet Radio and produces a quarterly magazine DATACOM. For the general radio amateur or short wave listener, there is the Radio Society of Great Britain (RSGB), which produces a monthly magazine RadCom.

Further Reading

There are many books which are generally aimed at radio amateur TNC users, but there is much general information for Packet Radio MODEM users.

Packet Radio Primer by Dave Coombe G8UYZ, and Martyn Croft G8NZU.

Newnes Amateur Radio Computing Handbook by Joe Pritchard G1UQW. (WT17T).

Amateur Radio Operating Manual by R. J. Eckersley G4FTJ. (WS13P).

DATACOM Winter 1993 by British Amateur Radio Teledata Group (BARTG).

Direct Software Addresses

The software packages mentioned in the article are available from the following suppliers:

BayCom – R. Dussmann & Partner GBR, Abt. Technische Dienste, Bert-Brecht-Weg 28, 30890 Barsinghausen, Germany.
Tel: +49 5105 83183.
Fax: +49 5105 83449.

Eskay Packet SP – Fa. Siegmund F. Kluger, Richard-Strauss-Str 19, D-816677 Munchen, Germany.
Tel: +49 89 45501080

MultiUser BayCom – Jon Welch G7JJF, 50 Quarrydale Road, Sutton-in-Ashfield, Nottingham NG17 4DR.

Graphic Packet – Ulf Saren, DH1DAE, Veit-Stoss-Str. 36, D-57076 Seigen, Germany.

Poor Man's Packet – Andrew C. Payne, Route 3, Box 78-Q, Berkley Springs, WV 25411, USA.

Please note:

Addresses and phone/fax numbers of suppliers listed are believed correct at time of writing.

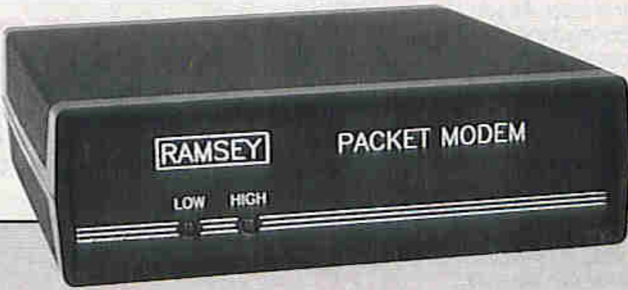
Maplin Electronics plc does not have any connections with the suppliers listed below and is therefore unable to answer any queries relating to their products.

Maplin Electronics plc does not give or imply any warranty or endorsement to the software packages mentioned.

Any money sent to the suppliers listed is at the sole risk of the sender.

Acknowledgments

Thanks are due to Waters and Stanton Electronics of Hockley for supplying the Packet Radio MODEM for review. Thanks are also due to the copyright holders of the software packages for granting permission for photographs of screen displays to be reproduced.



PACKET RADIO MODEM PARTS LIST

RESISTORS: All 5% Metal Film (Unless specified)		
R15,17	100Ω	2
R13,14	470Ω	2
R18	2k2	1
R5	4k7	1
R4,6,12	10k	3
R8,16	15k	2
R11	33k	1
R1,2,7,10	100k	4
R3	2M2	1
R9	10k Min Potentiometer	1
CAPACITORS		
C6,9	33pF	2
C1,3,5,8,10, 12,13,15,17	1nF	9
C7	100nF	1
C2,4,14,16	10μF 35V Electrolytic	4*
C11	220μF 25V Electrolytic	1

* This value may be changed, i.e. 10μF to 4μ7F with no effect on performance.

SEMICONDUCTORS		
Q1	2N3904	1
D1,2,4,6,7	1N4148/1N914	5
D3,5	LED	2
U1	74HC04	1
U2	TCM3105	1
VR1	7805	1
MISCELLANEOUS		
	PCB	1
Y1	4·4336MHz Crystal	1
J1	PCB Mount 9-way D Connector	1
J2	PCB Mount 5-pin DIN Socket	1
	Leaflet	1

OPTIONAL (Not in Kit)			
	Case	1	(CP37S)
	14-pin DIL IC Socket	1	(BL18U)
	16-pin DIL IC Socket	1	(BL19V)
	5-pin DIN Plug 180° Type A	1	(HH27A)
	4-core Individually Screened Cable	As Req.	(XR23A)
	8-core Braided Screen Cable	As Req.	(XS19V)
	7-pin Audio Plug (Yaesu)	As Req.	(FK27E)
	8-pin Audio Plug (Alinco Icom,Kenwood, Yaesu)	As Req.	(FK29G)
	3·5mm Stereo Jack Plug	As Req.	(HF98G)
	9-way D-type Plug	As Req.	(RK60Q)
	9-way D-type Socket	As Req.	(RK61R)
	25-way D-type Socket	As Req.	(YQ49D)
	9-way D-type Metallised Hood	As Req.	(JB68Y)
	25-way D-type Metallised Hood	As Req.	(JB08B)
	Constructors' Guide	1	(XH79L)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available in kit form only.

Order As CP36P (Packet Radio MODEM) Price £59.95 AO

Order As CP37S (C-IBM Case) Price £14.95 AO

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

AIR YOUR VIEWS

Dear Editor

S·T·A·R L·E·T·T·E·R

This issue Miss F. Mitchell, of Oxford, wins the Star Letter Award of a Maplin £5 Gift Token in reply to one of last month's letters.

What Does it All Mean?

Dear Editor,
As a subscriber to your magazine I look forward to receiving my monthly copy, and upon receipt of the May issue I thought I would drop you a line to ask a question which, hopefully, Maplin expertise can answer!
Following a working life in the communications industry I am now retired, and indeed fall into the 'mauve band' age group of your readership survey. I find the magazine extremely interesting although I have not as yet undertaken any projects, for a considerable number of them were my 'bread and butter' whilst working with technology albeit considered dated these days.
Since retiring in 1990 I have become involved in certain charitable enterprises for which I purchased an IBM PS/1 (2011) computer, with which I am producing this letter. As you may be aware this machine has an 80286 processor; whilst more than adequate for simple tasks, it is nevertheless slow for more complicated programs, as when our grandchildren want to play some of the more complicated games now on the market. To make matters worse my machine only has 1 meg of RAM!
While the RAM can be easily upgraded to 2 meg or more, I cannot find a definitive answer regarding replacement of the 80286 processor, with say an 80386, let alone an 80486. I have read numerous books, e.g., 'How to Expand, Modernise and Repair PCs and Compatibles', but still have not come up with a definitive answer. Can you help?
Michael G. Hersey, Essex.

Probably the easiest way to upgrade to a more modern, faster processor is to replace the motherboard with a 'third party' one (i.e. non-IBM). Generally speaking, most PC compatible computers follow the industry standard in terms of ISA expansion bus (the normal sort for address, data and power lines). Where this is the case, it is simply a matter of dismantling the case, unplugging the cards, removing the old motherboard, replacing it with the new one and reversing the disassembly procedure (as they say in the best workshop manuals).
Modern motherboards are about half the size of their predecessors, so it is sometimes necessary to extend cables and drill extra fixing holes. Older motherboards normally use soldered-in DIL RAM ICs, whereas new ones use plug-in SIMM RAM modules, which are easily upgradable; hence it is likely that SIMM RAM will have to be purchased as well. I have followed this route several times and upgraded two Dell 12MHz 80286 machines in this way.
The procedure can be repeated at a later date to upgrade to a '486 processor. Some motherboards will allow the processor to be changed, but it is often no more expensive to replace the whole motherboard! Maplin, can supply the parts you need. Beware, though, that there are some traps to fall into, the commonest being: non-standard case sizes and designs; horizontal instead of vertical expansion slots for plug-in cards; and, in older machines, hard disk drives with very old formats which are impossible to use with more modern disk controllers.

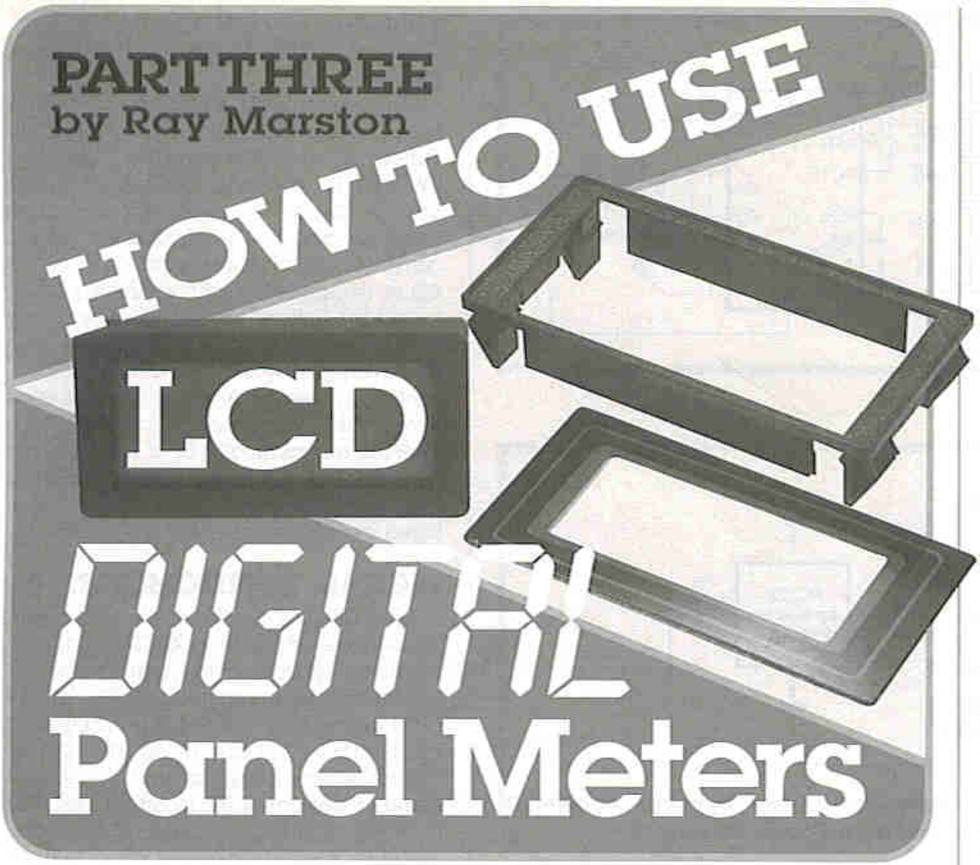
In Our Defence

Dear Editor,
I don't usually write to magazines, but I feel compelled to defend my generation against J. C. E. Moore's comments under 'Noisy Buildings' ('Air Your Views', Issue 77). I am an electronics student and, at the tender age of 19, I do not believe that most problems have been solved. One of our lecturers said recently that an engineer should never be out of work, as for each problem solved he (or she) creates at least five more! How very true.
I do agree that young people do not have all the answers, but perhaps if people, both young and old, were not so scared to listen to others outside their own age group, then most of the answers could be found. A lot of people believe that they come up with their best ideas while young, and that the young, like myself, can often give a more simplistic and useful approach to a problem. But we need the older people, with the experience, to stop thinking as if they know it all, and help us put our ideas into practice.
Experience often leads to a closed mind which may not explore all possibilities, usually missing out the obvious or simple. So instead of criticising the young, maybe more older people should work with them. I'm sure all electronics enthusiasts would benefit.
On a different note, the magazine has proved very helpful with my studies, especially on the practical side. I think it might be a nice idea to have some articles from professional electronics engineers about their work, and from hobbyists on the kind of things they get up to. I'd also be interested to hear from any females out there (if there are any), as I'm finding it a bit lonely being one of only two females on my course.

It is reassuring to find that, in fact, the up-and-coming young folks have got their heads screwed on. We just wish that, going by the readership survey, more of them would buy our magazine!

Not as Bad as it Sounds

Dear Sir,
I read with interest the 'Automotive Amnesia' letter in Issue 77, and felt the need to make some comment on the points raised.
I too look forward to anything automotive related, and I am an electronics technician with a keen interest in cars and associated electronic systems.
Firstly, I agree with Mr. Adams' point about security coded audio systems, but that about engine management systems need clarifying.
It is true that there are settings stored in RAM which are lost when the power is removed, but there are some other settings stored in ROM which act as an emergency 'limp home' system. These also form the basis for the management system, which allows the car to be driven until the system 'learns' a set of optimum settings, which can only be done by driving the car for 10 to 15 miles, and these are then stored in the RAM. I know this to be true from reading many articles on the subject, and also by removing my battery on a couple of occasions to find that the car, although it will start and run, is very underpowered for the first 10 miles or so.
Secondly, I would consider plugging a 9V PP3 battery into the cigarette lighter socket very dangerous, as the car battery, being 12V, would try to charge the PP3 at a high current until disconnected; which of course can be avoided by using a blocking diode. But this would bring the 'back-up' voltage down to 8·4V or so from a good PP3, and when you consider what needs to be backed-up – radio, car clock, management RAM, etc. – the PP3 wouldn't last very long! I would recommend 2 x 6V batteries or 1 x 12V battery rated at 1Ah



PART THREE by Ray Marston HOW TO USE LCD DIGITAL Panel Meters

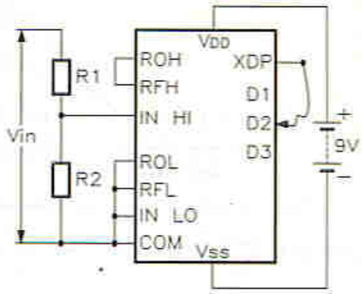
Last month we introduced and described the two DPM modules, currently stocked by Maplin. This part describes more detailed applications that can, with very minor modifications, be used with these or any other types of DPM. In these, 'conventional' terminal notations are used, in which the notations RFH, RFL, ROH, and ROL correspond to the Maplin module notations 'REF HI', 'REF LO', 'REF +', and 'REF –' respectively. Similarly, 'conventional' DP notations are used, in which DP1 corresponds to the left-hand decimal point.

DC VOLT AND CURRENT METERS

A DPM module is usually supplied ready-calibrated to give a full-scale reading of ±199·9mV DC. It can be made to give alternative full-scale DC voltage readings, at an input impedance of 10MΩ, by connecting the input voltage to the module via a decade potential divider, as shown in Figure 36. Alternatively it can be made to act as a DC current meter by wiring a suitable shunt resistor across the input terminals, as shown in Figure 37. Note in both diagrams that the appropriate decimal point of the display must be activated, as shown.

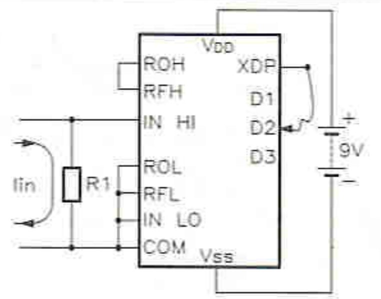
The module can be used as a 5-range DC voltmeter by using the connections shown in Figure 38. The table provides alternative component values for the potential divider to give input impedances of either 10MΩ or 11·11MΩ. Ideally, all multirange circuits should be fitted with some form of overload protection, and in the diagram this is given by fuse F1 and a Voltage-Dependent Resistor (VDR) or 'transient suppressor' across the divider. Note that on the '1·999kV' range the maximum input is actually limited to 700V by the VDR.

The DPM module can be used as a 5-range DC current meter by using the connections shown in Figure 39. The generated voltages of the shunts are directly read by the module, and variations in the switch resistance of SW1a have no effect on the accuracy of measurement. Note that a separate input terminal is used for the '2 Amp' measurement, and that overload protection is provided by D1, D2 and F1.



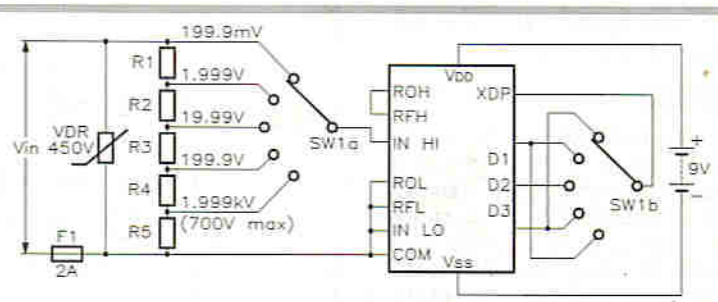
R1	R2	$V_{full\ scale}$	Decimal point high
0	10M	199·9mV	D3
9M0	1M0	1·999V	D1
9M9	100k	19·99V	D2
10M	10k	199·9V	D3
10M	1k0	1·999kV	D1

Figure 36. A DPM can cover different DC voltage ranges by connecting the input through a potential divider.



R1	$I_{full\ scale}$	Decimal point high
10k	19·99µA	D2
1k0	199·9µA	D3
100Ω	1·999mA	D1
10Ω	19·99mA	D2
1Ω0	199·9mA	D3
0Ω1	1·999A	D1
0·01Ω	19·99A	D2

Figure 37. A DPM can be made to read DC current by connecting a shunt resistor across its input.



R1	R2	R3	R4	R5	Input Z
9M0	900k	90k	9k0	1k0	10M
10M	1M0	100k	10k	1110Ω	11·11M

Figure 38: (a), 5-range DC voltmeter; (b), alternative attenuator values.

AC VOLT AND CURRENT METERS

Figure 40 shows how the circuit of Figure 38 can be modified to act as a 5-range AC voltmeter with a frequency response that is flat within 1dB to about 120kHz.

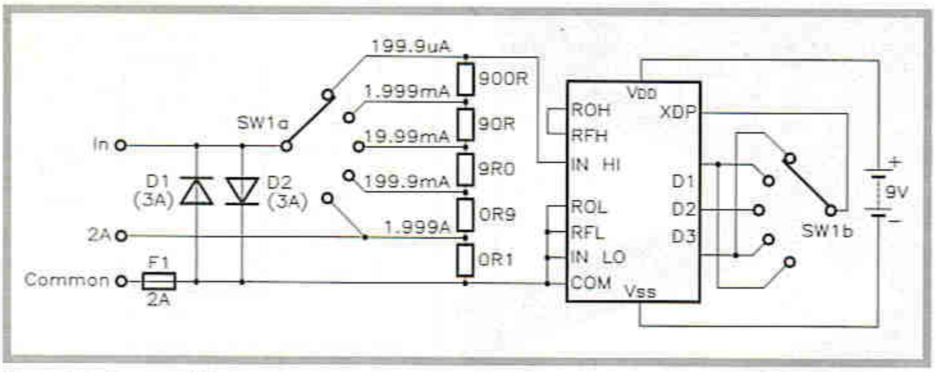


Figure 39. 5-range DC current meter.

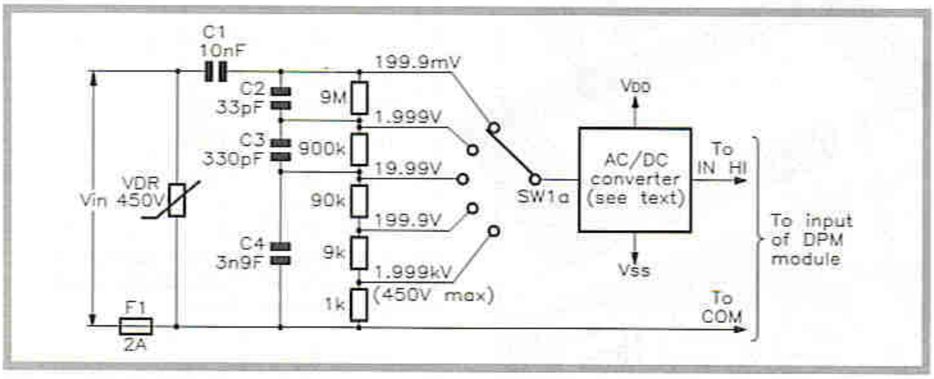


Figure 40. Modification to the circuit of Figure 38, making a 5-range AC voltmeter.

Input signals are fed to the attenuator via DC blocking capacitor C1, and the attenuator is frequency-compensated by C2 to C4. The attenuator output is fed to the input of the DPM via a precision AC/DC converter, which gives a DC voltage output equal to the rms value of a sinewave input.

Figure 41 shows how the circuit of Figure 39 can be similarly modified to act as a 5-range AC current meter. In this case it is not feasible to prevent DC currents feeding into the shunts. Instead, DC-blocking is done at the output of the shunts by C1 & R1, and the resulting AC signals are fed to the input of the DPM via a precision AC/DC converter. Input protection is provided by F1 and two pairs of series-connected diodes.

Figure 42 shows the circuit of the precision AC/DC converter recommended for use with the above two circuits. The design uses BAT85-type Schottky diodes as signal rectifiers. The gain of the converter can be set to precisely 2·2 by RV1, to give a DC output that is equal to the rms value of a sinewave input. The converter is powered from the DPM's supply rails and is designed around an LF355 op amp, which can operate well from the 2·8V between V_{DD} and COM.

OHMMETERS

The easiest and best way to use a DPM as a resistance (ohm) meter is to use it in the ratiometric configuration already described. This technique has two major advantages. First, it is very stable and inherently self-calibrating, the meter reading being equal to $R_x \times (rat/R_{ref})$, where 'rat' is the DPM's ratiometric value: 'rat' is typically only 0·1% low (0·1% below unity), so measurement accuracy is determined primarily by R_{ref}. The second advantage is that very low test voltages are generated across R_x. At most these are only $^2/_3$ of the energising voltage (typically 100 to 300mV at full-scale). Figure 43 shows how a DPM can be connected as a practical 5-range ohmmeter.

A 25-RANGE DIGITAL MULTIMETER (DMM)

Figure 44 shows how the circuits of Figures 38 to 43 can be joined to make a complete 5-function, 25-range digital multimeter, or DMM, and the table of Figure 45 lists the ranges and functions of the meter.

The reader should have little difficulty in following the circuit of Figure 44. Functions are selected by SW1, ranges by SW2. SW1a connects the inputs to the voltage, current, or resistance measuring networks, and SW1d activates the AC/DC converter (which is the same as in Figure 42) or energises the 'ohms' circuitry when necessary. Voltage ranges are selected by SW2a, current ranges by SW2b, and resistance ranges by SW2c. SW2d and SW2e control the decimal point position on each range, the appropriate switch being selected automatically by IC2a. IC2b and IC2c control the basic configurations of the DPM module. IC2 (a triple 2-way analogue switch) is activated via SW1d.

DIGITAL THERMOMETERS

A DPM module can be made to act as a wide-range (-50°C to +150°C) digital thermometer by feeding the output of a linear voltage-generating temperature sensor to its inputs. Two types of sensor are readily available, the first being an ordinary bipolar silicon transistor, and the second being a dedicated IC. In either case the resulting digital thermometer has a temperature discrimination of 0·1°C, with a linear accuracy varying from 0·5°C to 1·5°C, depending on the type of sensor and circuitry used.

Because of its low mass, a transistor sensor has a thermal response time some 10 to 100 times faster than a normal mercury thermometer. When used to measure sharp changes in the temperature of free air, a transistor-sensor circuit typically settles to within 0·1°C of the new tempera-

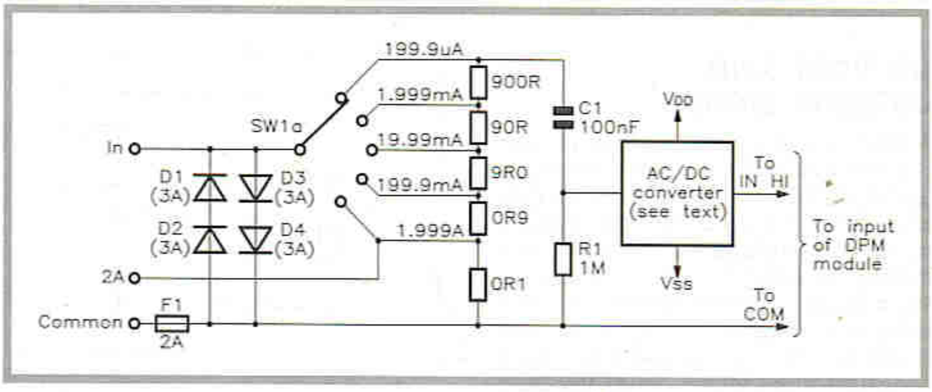


Figure 41. Modification to the circuit of Figure 39 making a 5-range AC current meter.

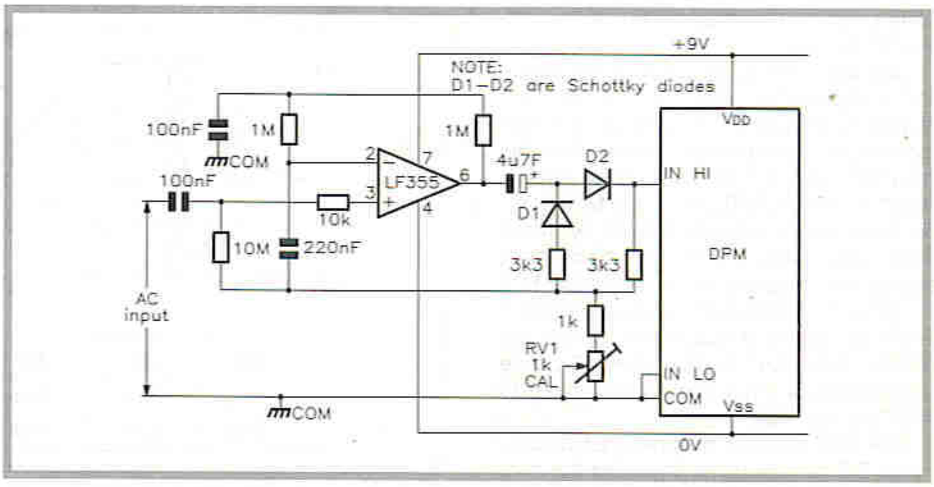


Figure 42. Precision AC/DC converter.

ture within one minute, whereas a mercury thermometer takes some 20 minutes to attain the same accuracy.

TRANSISTOR-SENSOR CIRCUITS

When an ordinary NPN silicon transistor is connected as in Figure 46 (a) and is biased from a constant-current source, it generates an output voltage that is directly proportional to the transistor's temperature. This voltage has a temperature coefficient of about -2mV/°C, and typically varies from about 600mV at 0°C to about 400mV at 100°C, as shown in the idealised graph of (b). In practice the 'straight line' of the graph is linear, within about 1mV, over the full range of 0°C to 100°C, but the exact voltage generated at any given temperature depends on the individual transistor and its operating current. Errors due to self-heating effects are negligible at operating currents below 100μA, and (c) shows the typical voltage variation (at 25°C) over the 10 to 40μA operating current range.

Figure 47 shows a practical example of a simple digital thermometer that uses a transistor sensor and gives a direct readout in °C, and has a linear accuracy within 1·5°C over the 0°C to 100°C range. A stable 2·8V is generated between V_{DD} and COM of the DPM module, so R1 drives the sensor transistor with a current of 22μA at 0°C, rising to about 24μA at 100°C. (This current variation causes most of the 1·5°C linear error of the circuit.) The sensor's output is fed directly to the DPM's IN LO terminal, and a 600mV (nominal) offset voltage (equal to the sensor voltage at 0°C) is fed to IN HI. A 200mV (nominal) reference voltage (equal to the difference between the generated 0°C and 100°C voltages) is fed to the DPM's RFH terminal. The DPM responds to the differential or 'IN HI minus IN LO' of its input, thus at 0°C

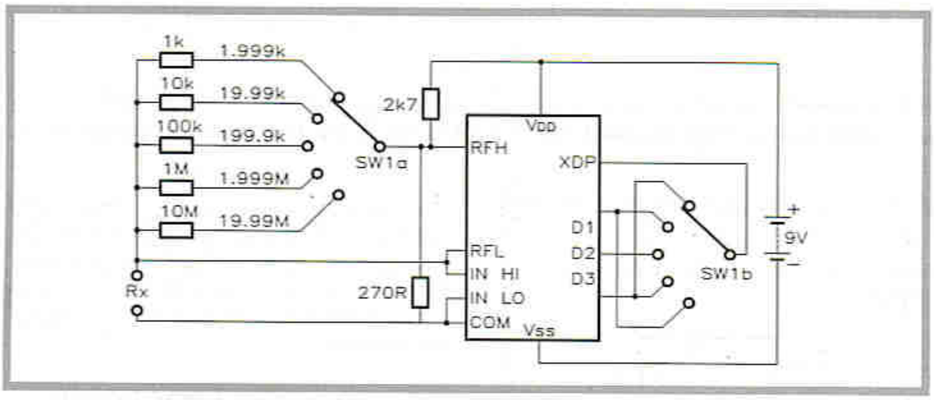


Figure 43. 5-range digital ohmmeter.

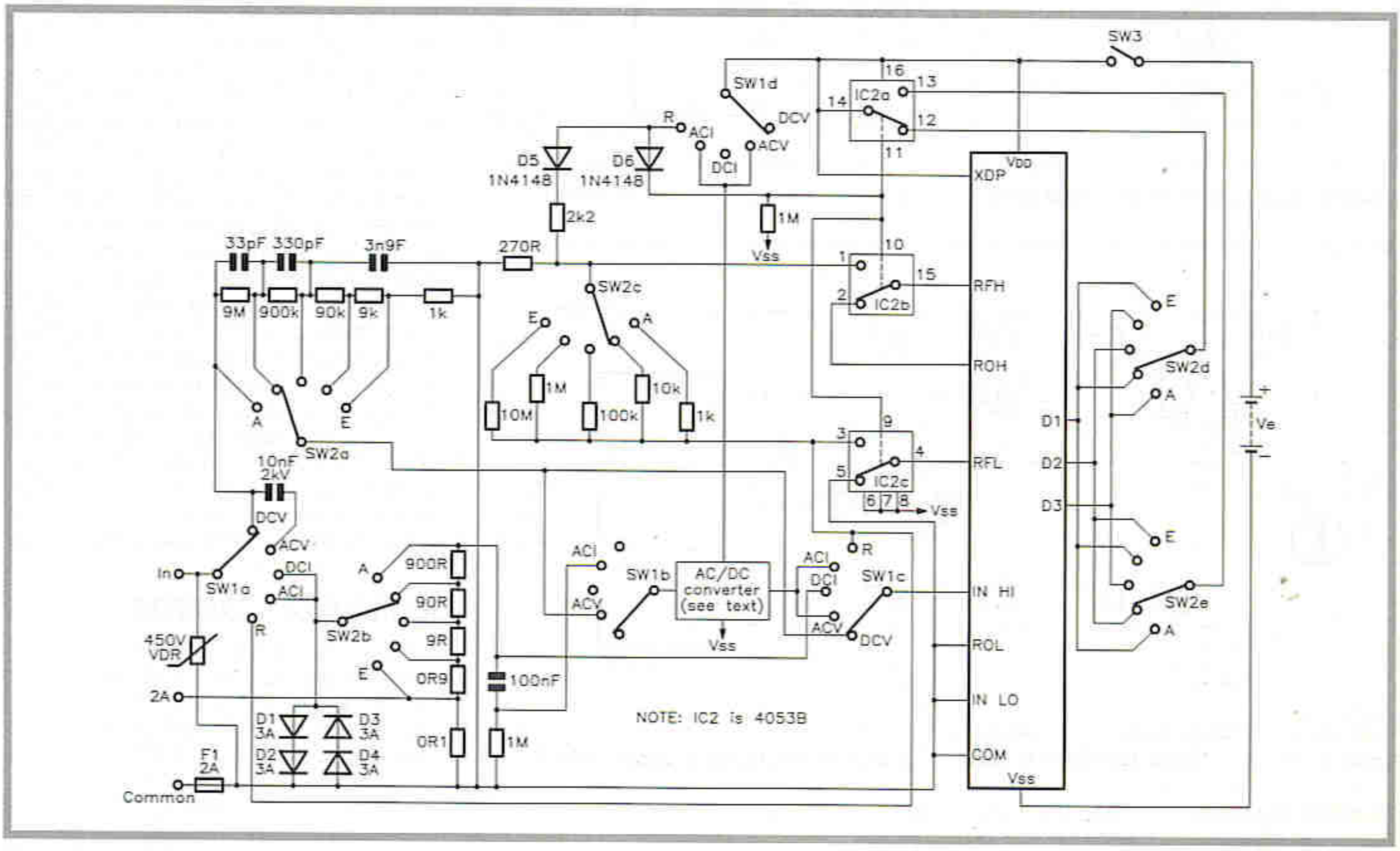


Figure 44. Complete 5-function 25-range multimeter.

MODE (SW1)	RANGE (SW2) A	B	C	D	E
DCV	199·9mV	1·999V	19·99V	199·9V	1·999kV (700V max.)
ACV	199·9mV	1·999V	19·99V	199·9V	1·999kV (450V max.)
DCI	199·9μA	1·999mA	19·99mA	199·9mA	1·999A
ACI	199·9μA	1·999mA	19·99mA	199·9mA	1·999A
R	1·999kΩ	19·99kΩ	199·9kΩ	1·999MΩ	19·99MΩ

Figure 45. Table of ranges and functions of the 25-range multimeter.

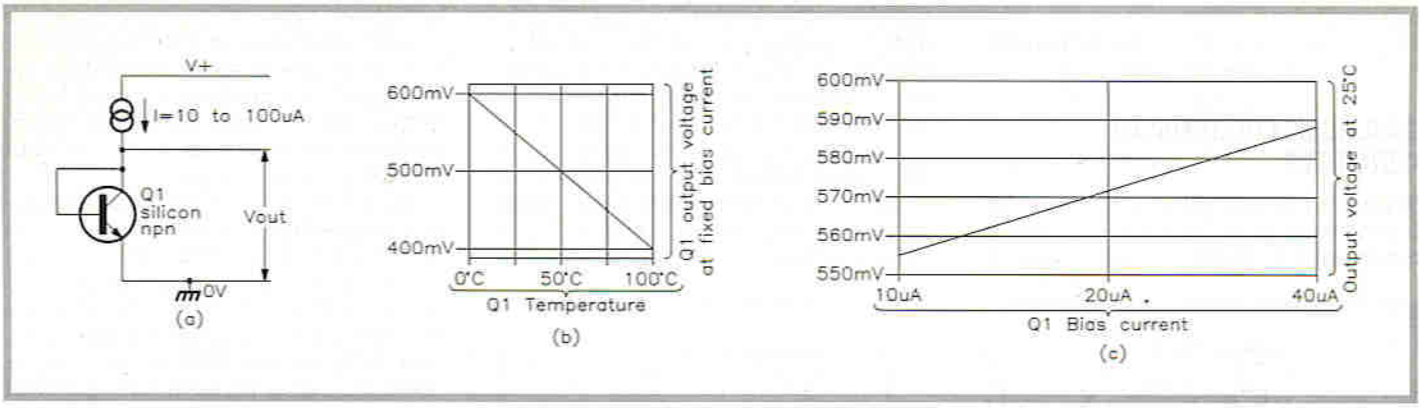


Figure 46. When a transistor is connected as in (a), its output voltage varies by about -2mV/°C, as shown in (b). The output voltage also varies with drive current, as shown in (c).

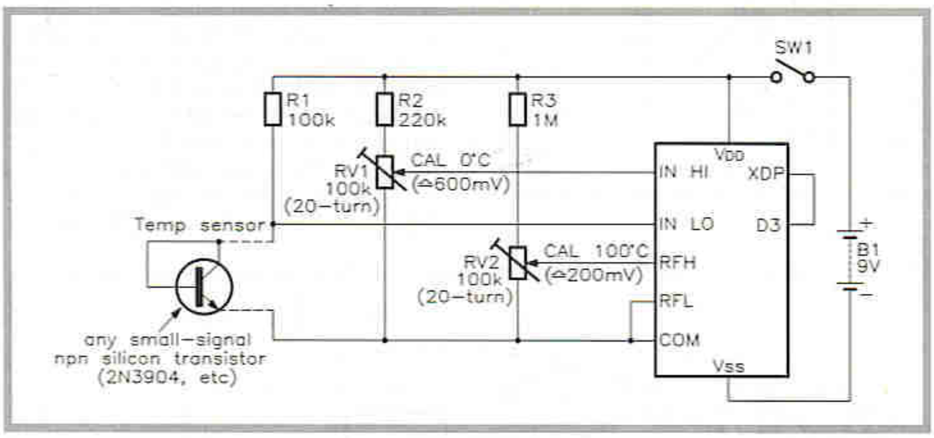


Figure 47. Simple Digital Thermometer using a transistor sensor. Linear accuracy is about 1·5°C.

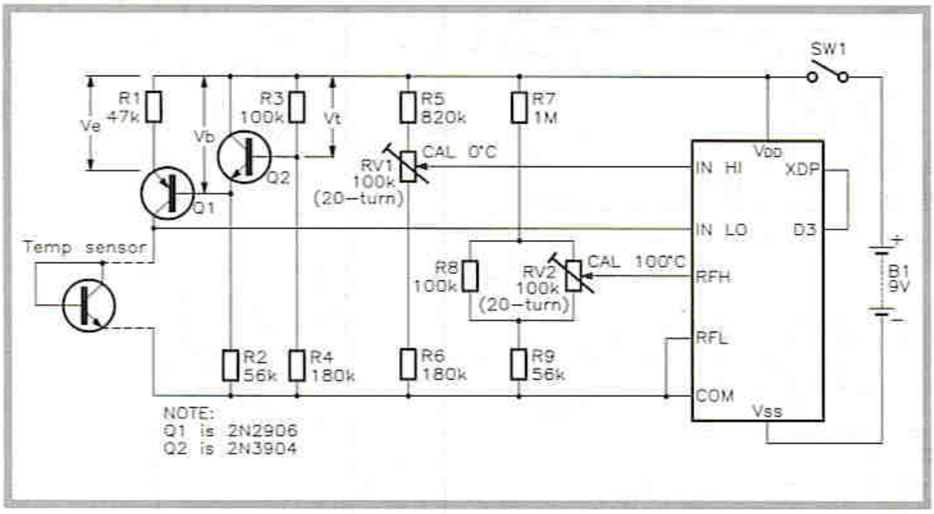


Figure 48. Precision Digital Thermometer using a transistor sensor. Linear accuracy is 0·5°C.

the meter sees 600mV - 600mV = 0mV, and gives a reading of '00·0 °C'. But at 100°C it sees an input of 600mV - 400mV = 200mV and (since 200mV is applied to RFH) gives a reading of '100·0 °C'.

Figure 48 shows a 'precision' version of the above thermometer circuit. This design has a linear accuracy of about 0·5°C, and its transistor sensor is energised at about 20µA by constant-current generator Q1, which is temperature compensated by Q2. Here, the divider R3 & R4 (wired between V_{DD} and COM) generates a voltage V_t (about 1V) across R3, and this voltage is 'followed' by Q2 and causes voltage V_b (equal to $V_t + V_{be}2$) to appear on Q1 base. The 'V_e' voltage appearing on the emitter of Q1 is thus equal to $V_t + V_{be}2 - V_{be}1$. Note, however, that since Q1 and Q2 operate at near-identical temperatures and at similar current levels, the $V_{be}1$ and $V_{be}2$ values cancel out at all operating temperatures, and V_e is thus equal to V_t. The constant-current output of Q1 equals $V_t/R1$, and is independent of variations in ambient temperature.

CALIBRATION PROCEDURE

To calibrate the above two 'thermometer' circuits, firstly make up the transistor sensor and its flexible leads, then coat all sensitive parts with insulating varnish. When the varnish has dried, mix a quantity of crushed ice and cold water in a tumbler (to act as a 0°C reference). Immerse the sensor into the tumbler, and adjust RV1 to give a reading of '00·0' on the DPM. Finally, remove the sensor from the tumbler and immerse it in gently simmering boiling water (to act as a 100°C reference), then adjust RV2 to give a meter reading of '100·0'. Basic calibration is then complete. If the meter is to be used around some nominal average value during its working life, such as 25°C, then RV1 can (after the initial calibration above) be altered to set the meter 'spot on' at that value, by immersing the probe and a standard thermometer in a liquid that is raised to the desired temperature.

IC-SENSOR CIRCUITS

Several companies manufacture dedicated temperature-sensor ICs suitable for use in DPM-based digital thermometers. One such device is the GE/Intersil AD590. Essentially a 2-pin IC (but with a third pin

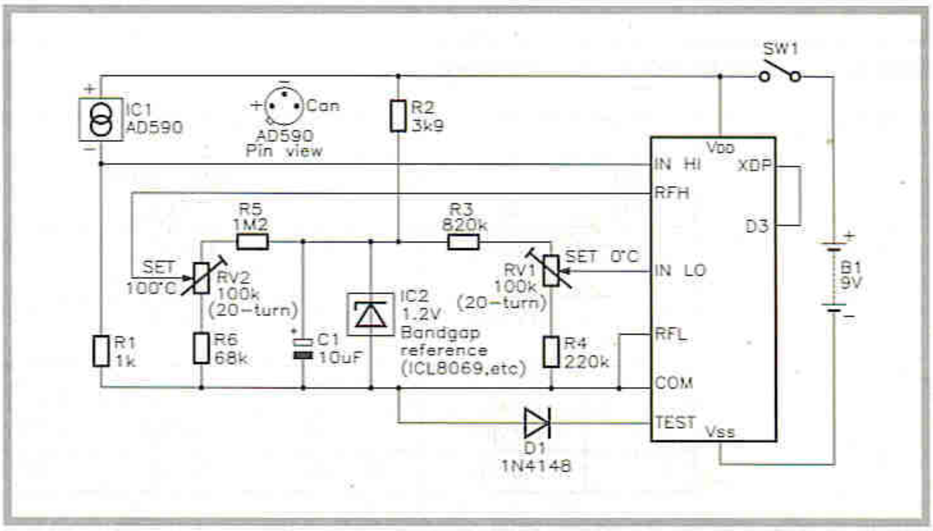


Figure 49. Digital Thermometer based on the AD590 temperature-sensor IC.

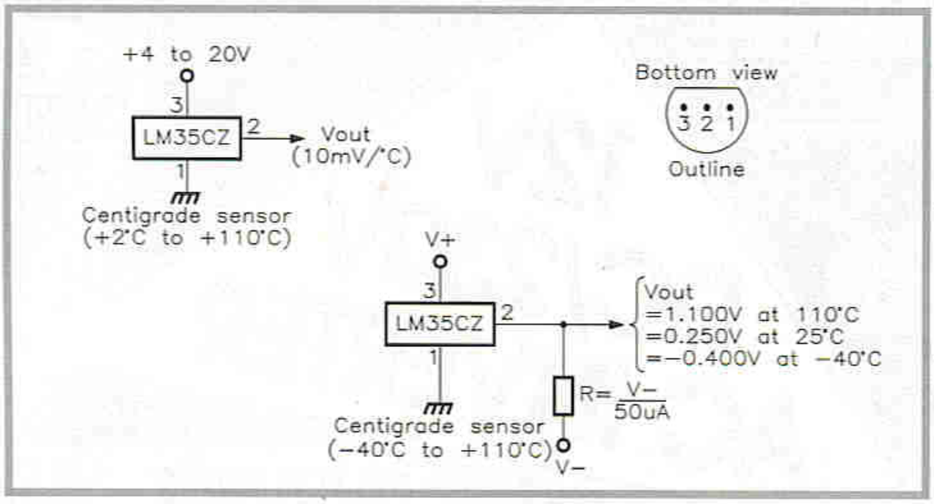


Figure 50. LM35CZ outline and basic application circuit.

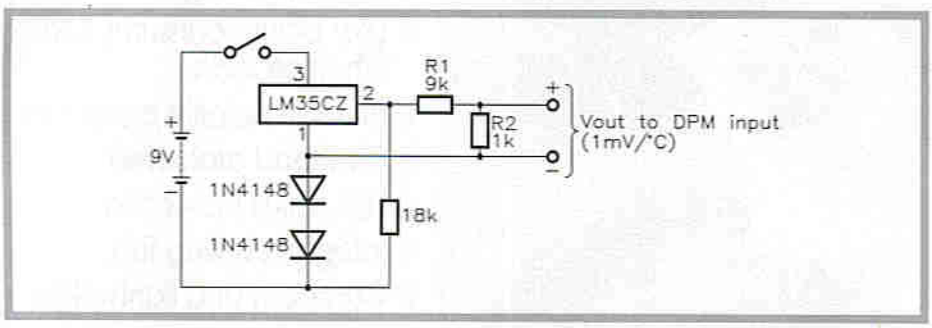


Figure 51. 'Stand-alone' IC temperature converter, for use with a 0 to 200mV DC DPM.

shorted to its case), it gives an output current of 1μA/K which, when fed through a 1kΩ resistor, gives an output of 1mV/K. The non-calibrated 'spot' accuracy of the AD590 varies from 0·5°C to 10°C, and its linearity error from 0·3°C to 1·5°C, depending on the device's 'grade' (indicated by a suffix number). The 590kH version of the IC has a 'spot' accuracy of ±2·5°C at 25°C, and can be used over a temperature range of −55°C to +150°C. Figure 49 shows how an AD590 can be used with a DPM module.

The AD590 needs a supply of at least 4V, and this is obtained by wiring the IC between V_{DD} and TEST (which is internally maintained at 5V below V_{DD} in the DPM) via D1, which biases the COM terminal to about 600mV above TEST. R1 is wired in series with the AD590 and generates approximately 1mV/K (= 273·2mV at 0°C, 373·2mV at 100°C), and this voltage is fed to the IN HI terminal. A bandgap reference, IC2, generates a stable 1·2V, which is divided down by R3, RV1 & R4 to give a 'SET 0°C' offset voltage of nominally 273·2mV at IN LO. The bandgap reference voltage is also divided down by R5, RV2 & R6 to provide a 'SET 100°C' scaling voltage of nominally 100mV at RFH. The circuit must be calibrated in the way already described for the designs shown in Figures 47 and 48.

An even more useful temperature sensor IC is the LM35CZ, from National Semiconductors. This three-terminal IC is housed in a plastic TO92 package and gives a linear output voltage of 10mV/°C, with a typical accuracy of ±0·4°C at 25°C, and can be used over the temperature range −40°C to +110°C. The IC must be powered from a supply in the range of 4 to 30V. It typically consumes 90μA at 5V, has a very low output impedance (typically 0·4Ω at a load of 1mA), and needs no external calibration. Figure 50 shows the IC's outline and basic application circuits. Note that if the IC is to be used to indicate sub-zero temperatures then R must be connected to its output (pin 2) and taken to a negative supply rail.

The major feature of the LM35CZ is that it needs no external calibration, and the best way to use it in DPM applications is as an add-on accessory for use with an existing DPM voltmeter. In this case the IC should be used as a 'stand-alone', independently powered unit as shown in Figure 51, with its output taken (when needed) to the '200mV DC' input of the DPM via the 10:1 attenuator R1 & R2.

Next month sees the final part of this series, which will feature capacitance and frequency meters based on DPM modules.

The reader is asked to note that this mini-series is based on Chapter 7 of the author's *Instrumentation and Test Gear Circuits Manual*, with the addition of extra material derived from data sheets supplied by Lascar Electronics Ltd. The book is available from Maplin, Order As AA37S price £16.95*NV*.

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THE LINCOLN SHORT WAVE CLUB meets every Wednesday night at the City Engineers' Club, Waterside South, Lincoln at 8pm. All welcome. Further details from Pam, G4STO (Secretary) Tel: (0427) 788356.

WIRRAL AND DISTRICT AMATEUR RADIO SOCIETY meets at the Irby Cricket Club, Irby, Wirral. Organises visits, DF hunts, demonstrations and junk sales. For further details, please contact: Paul Robinson (G0JZP) on (051) 648 5892.

CRYSTAL PALACE & DISTRICT RADIO CLUB. Meets on the third Saturday of each month at All Saints Church Parish Rooms, Beulah Hill, London SE19. Details from Wilf Taylor, G3DSC. Tel: (081) 699 5732.

WIRRAL AMATEUR RADIO SOCIETY meets at the Ivy Farm, Arrowe Park Road, Birkenhead every Tuesday evening, and formally on the 1st and 3rd Wednesday of every month. Details: A. Seed (G3FOO), 31 Withert Avenue, Bebington, Wirral L63 5NE.

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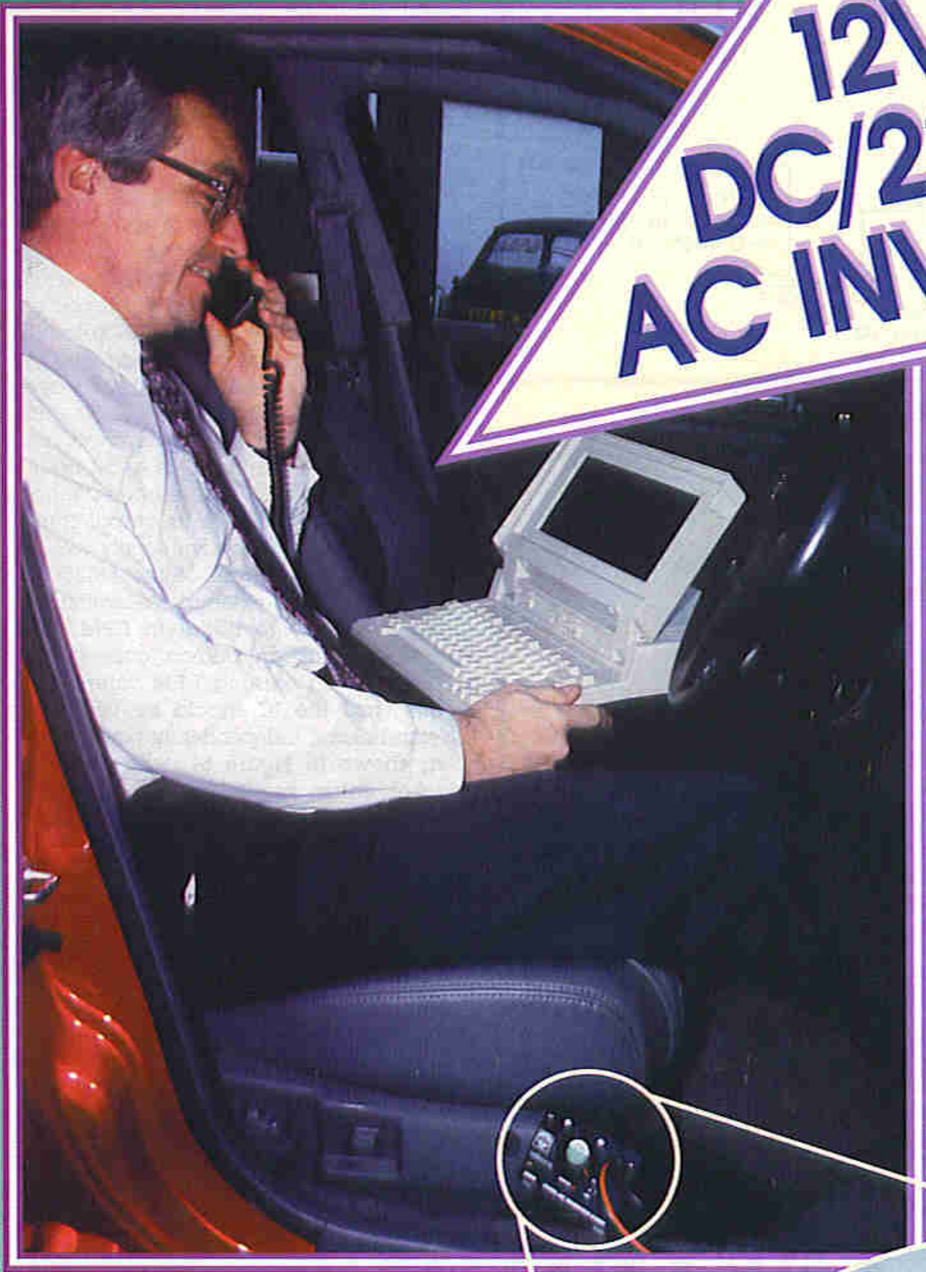
Text by Alan Williamson and Robin Hall

12V DC/230V AC INVERTER

4
PROJECT RATING



FEATURES

* High efficiency
* Low power consumption when off load
* Reverse polarity protected
* Overload protected
* LED status indication
* Integral cooling fan
* Compact and lightweight

APPLICATIONS

* Standby supply in case of mains failure
* Provides mains voltage in cars, caravans and on boats

This device enables mains operated equipment, with a power consumption of 250W or less, to be powered from a high current +12V DC power source. Power sources include a car battery or alternator. This could be very useful if you need 230V AC mains voltage in the event of a power cut, for example, to power an electric pump and timer circuit for gas central heating, or domestic electric lighting. It could even be used as a backup supply to protect sensitive computer equipment in the event of a power cut. Other uses may be to supply 230V AC in areas where it would not normally be present, such as in a car, caravan, outhouse, or even on a boat.

Kit Available
VF35Q
Price £119.95 B4

The assembled 12V DC/230V AC Inverter PCB ready for use.

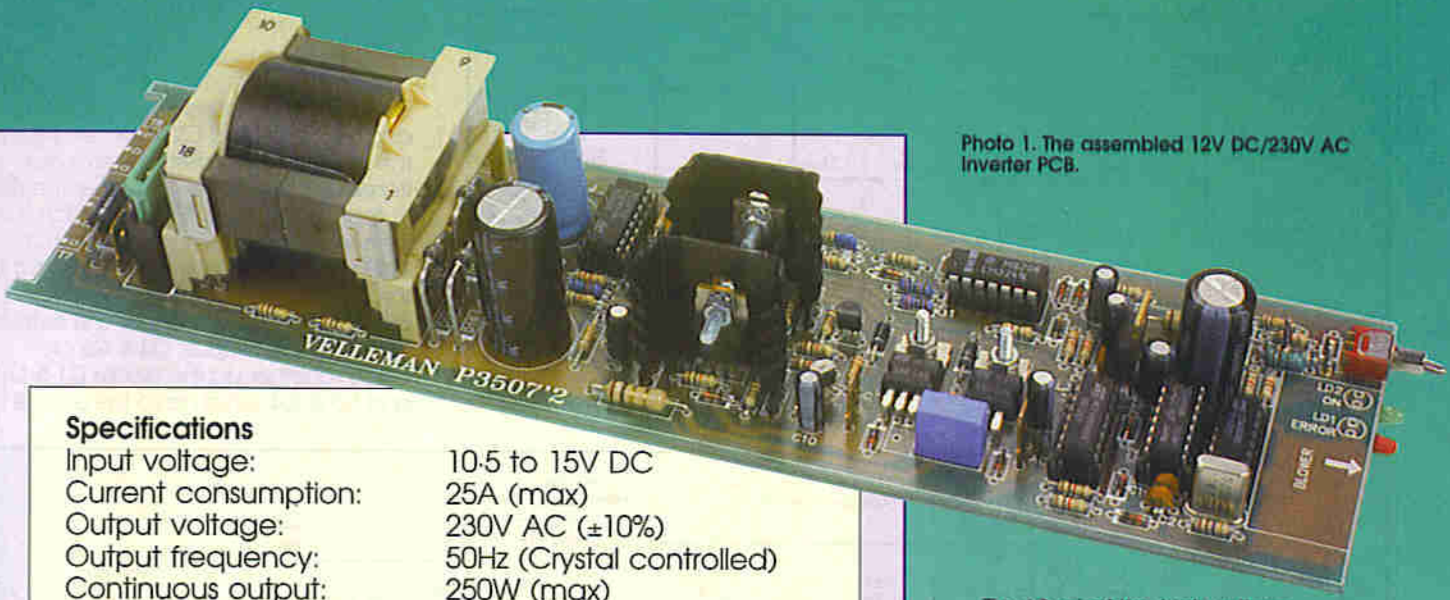


Photo 1. The assembled 12V DC/230V AC Inverter PCB.

Specifications

Input voltage:	10·5 to 15V DC
Current consumption:	25A (max)
Output voltage:	230V AC (±10%)
Output frequency:	50Hz (Crystal controlled)
Continuous output:	250W (max)
Peak output power:	500W
Efficiency:	80% (max)
Dimensions:	270 x 80 x 85mm
Weight:	1·4kg

Circuit Description

A block diagram of the Inverter is shown in Figure 1, and the 'quasi' sine wave output is shown in Figure 2. Referring to Figure 3 for the circuit diagram, note that reverse polarity protection of the circuit is provided by the fuse F1. In the event of wrong polarity connection, diode D17 will conduct and blow the fuse. This method of polarity protection is preferred to a series connected diode (as there is no voltage drop across the diode). This is important when the criteria for efficiency and energy is at a premium, especially when batteries are being used. Capacitor C18 provides the main decoupling in the circuit.

The switch SW1 turns the fan on as well as supplying power to the rest of the circuit. Resistor R45 is required to drop the excess voltage to the fan. Inductor (choke) prevents supply noise generated by the fan from upsetting the regulator VR1, which is required to regulate the supply to the ICs. The Zener diode ZD4 is not used on the +12V DC version and is replaced by a wire link.

Capacitors C16 and C6 provide low and high frequency decoupling at the input of the regulator, while capacitors C15 and C7 provide the same function at the output, as well as aiding stability.

The LED LD2 is the power on indicator, resistor R32 is the current limiting resistor.

The heart of the high voltage conversion system is IC4, a dedicated switch mode power supply (SMPS) IC. The frequency of the SMPS is determined by the components R31 and C3, in this case it is approximately 53kHz. Pin 16 is the reference voltage pin, and resistors R36 and R37 attenuate the reference voltage to the required level for the rest of the circuit. Pin 10 is the 'shutdown input'. Pins 11 and 14 are the outputs which control the MOSFETs T7 and T8 which are the push pull devices for driving the transformer.

The Zener diodes ZD2 and ZD3 are there to protect the driver MOSFETs T7 and T8 from the induced emf produced by the transformer caused by the collapse of the magnetic field. Capacitor C19 and resistor R41 form a Zobel network, which has a multifunction purpose; such as to act as a snubber to slow the rise time at switch on, and to effectively reduce any radiated harmonics, as well as to soften the decay of the magnetic field.

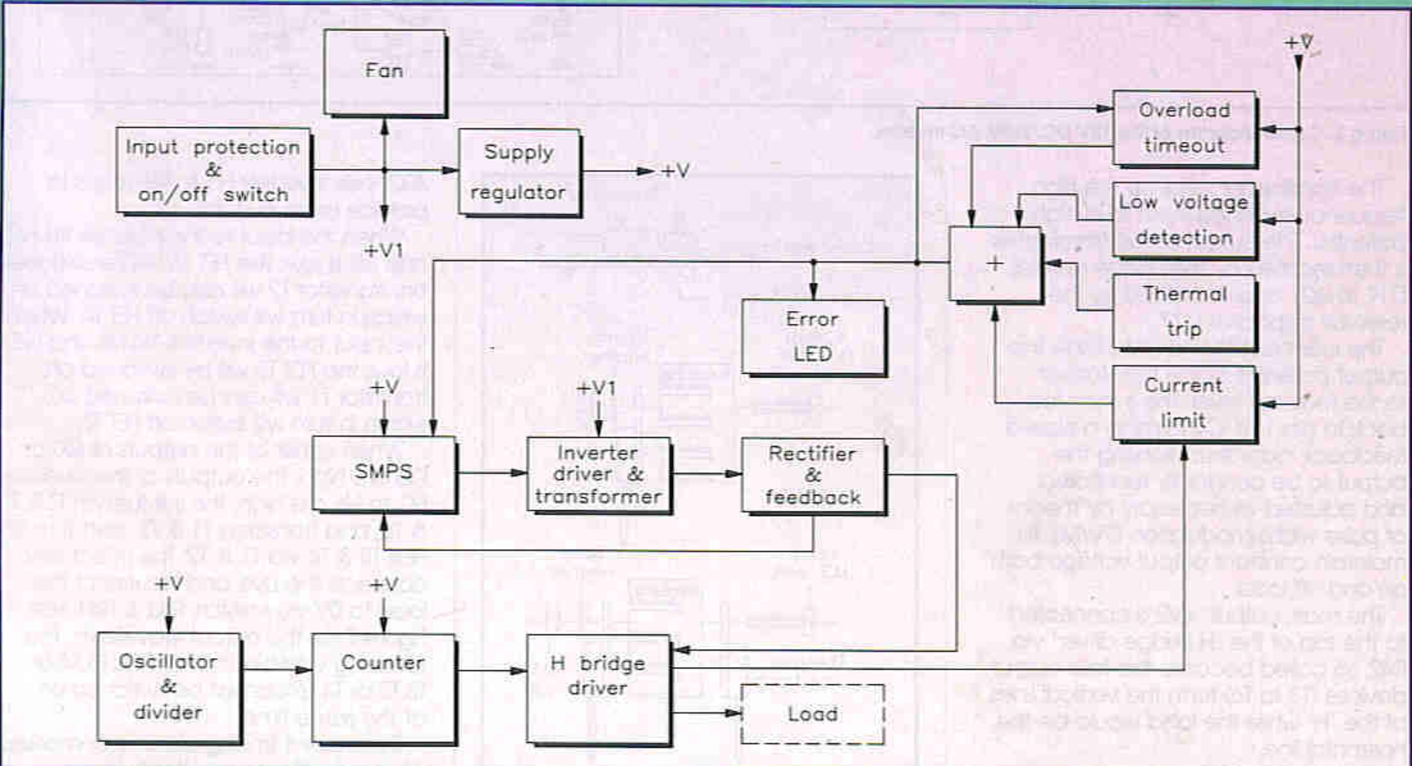


Figure 1. Block diagram of the 12V DC/230V AC Inverter.

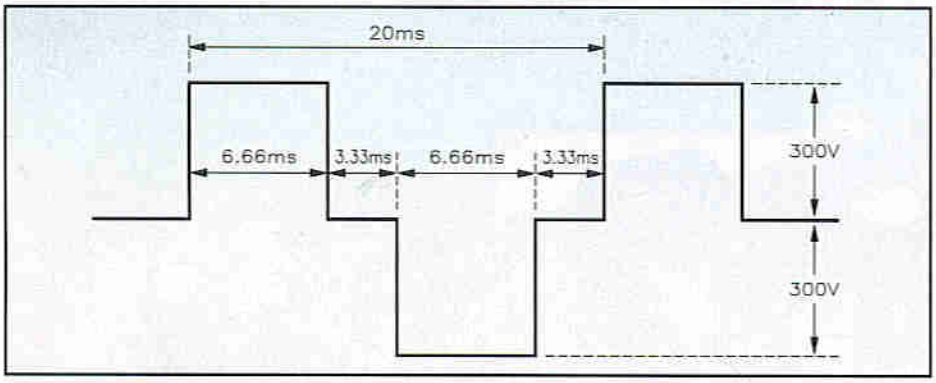


Figure 2. Quasi sine wave.

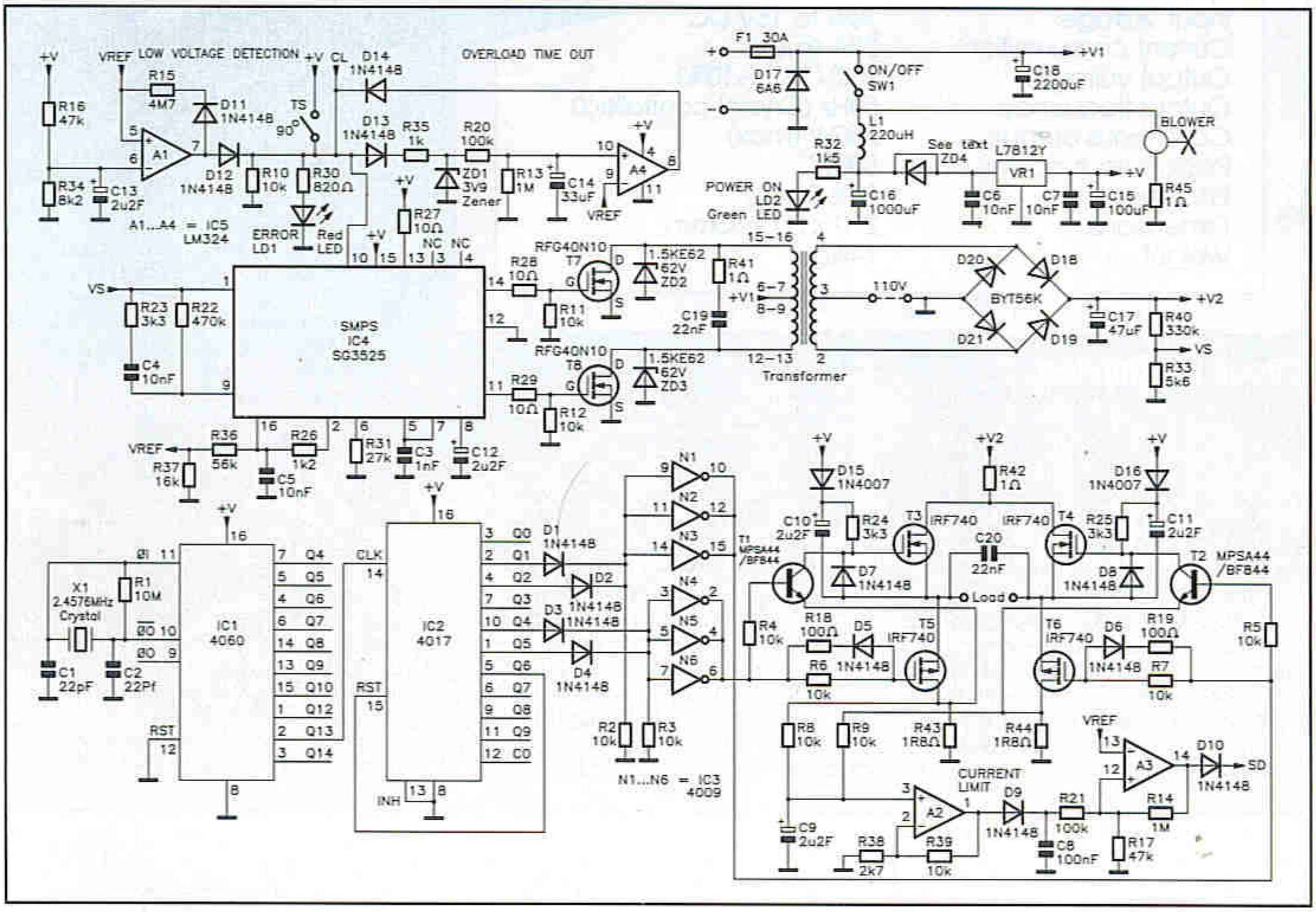


Figure 3. Circuit diagram of the 12V DC/230V AC Inverter.

The transformer steps up the high frequency switched input to a high potential. The output of the transformer is then rectified by the bridge rectifier D19 to D21 and smoothed by the reservoir capacitor C17.

The resistors R40 and R33 divide the output potential of the transformer to the required level. This is then fed back to pin 1 of IC4 forming a closed feedback loop; thus allowing the output to be constantly monitored and adjusted as necessary by means of pulse width modulation (PWM), to maintain constant output voltage both on and off load.

The main output, +V2 is connected to the top of the 'H bridge driver' via R42; so called because the four output devices (T3 to T6) form the vertical lines of the 'H' while the load would be the horizontal line.

IC1 is a 4060 14-stage ripple counter/oscillator; the oscillator section also comprises crystal X1, resistor R1 and capacitors C1 and C2. Each section of the ripple counter divides the crystal frequency by two for 13 stages; the final output frequency is 8·192kHz which is then fed to the clock input of IC2, a 4017 decade counter. The Q6 output of the 4017 is connected to the reset pin to provide the required count. The outputs Q1 & Q2 and outputs Q4 & Q5 are ORed together via the diodes D1 & D2 and D3 & D4, which feed the parallel 4009 hex inverters N1 to N6 (this is to provide more current).

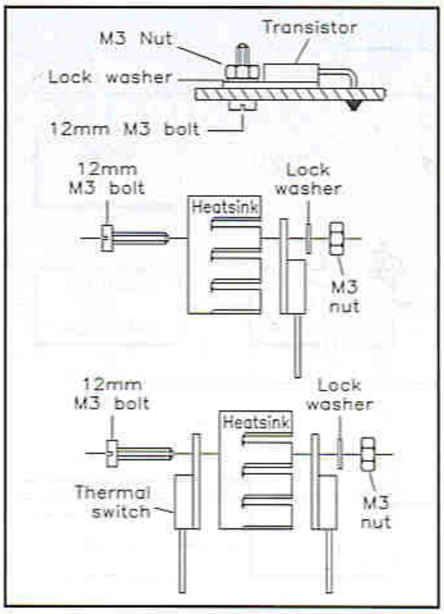


Figure 4. T3 to T6 mounting arrangements.

When the input to the inverters N1,N2 and N3 is low, the FET T6 will be switched on; transistor T2 will also be switched on; which in turn will switch off FET T4. When the input to the inverters N4,N5 and N6 is low, the FET T5 will be switched on; transistor T1 will also be switched on; which in turn will switch off FET T3.

When either of the outputs of Q0 or Q3 are high, the outputs of the inverters N1 to N6 are high; this will turn on FETs T5 & T6, and transistors T1 & T2; and turn off FETs T3 & T4 via T1 & T2; this effectively connects the Live and Neutral of the load to 0V via resistors R43 & R44; see Figure 2 for the output waveform. The following combination of FETs T3,T4 or T3,T5 or T4,T6 cannot be switched on at the same time.

The current limiting circuit is comprised of an amplifier to monitor the load current. This operates by using R43 and

Important Safety Notes:

NEVER CONNECT THE INPUT BATTERY TERMINALS DIRECTLY TO THE OUTPUT
Do not earth any side of the output to ground.
Do not operate the unit out of its case.
Do not touch the output connections.
Do not extend the battery connection wires.
Do not cover the ventilation holes.
Do not use in wet conditions.
Do observe the same precautions as you would the mains.
Do ensure that the power consumption is not more than 250W.
Do replace fuses with correctly rated ones.
Do place the inverter away from TVs as it may cause interference.

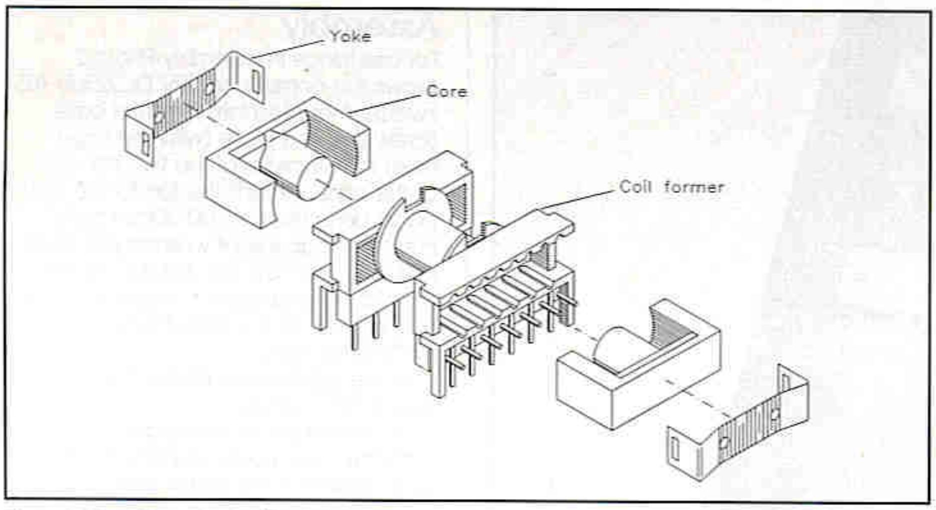


Figure 5. Transformer assembly.

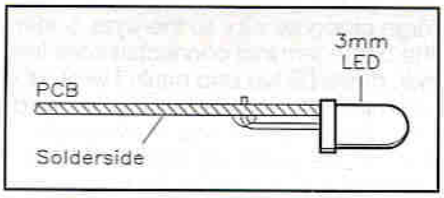


Figure 6. LED mounting.

R44 as current sensing resistors enabling the voltage to be measured and amplified with non-inverting amplifier A2, of which R38 and R39 set the gain. Diode D9 prevents A2 from sinking the voltage on the capacitor C8.

Opamp A3 is used as a Schmitt trigger, with R14 providing the positive feedback. If the voltage at the non-inverting input is higher than V_{ref}, then the output will latch high, and the output is then fed to the 'CL' junction via D10. CL (pin 10 of IC4) is the central connection of all the protection circuits, i.e. the under-voltage detection (A1), overload time out (A4) circuits and the thermal switch (TS). If any protection circuit operates, LD1 will illuminate. In any of these instances IC4 will be disabled by taking pin 10 high.

The low voltage detection circuit also uses Schmitt trigger, with R15 providing the positive feedback for hysteresis. The inverting input of A1 is connected to the potential divider R16 and R34, capacitor C13 'irons out' any small supply variations. If the voltage at inverting input of A1 drops below V_{ref}, the output will swing high and illuminate LD1.

The overload time out operates in the following manner: should any of the protection circuits trip; capacitor C14

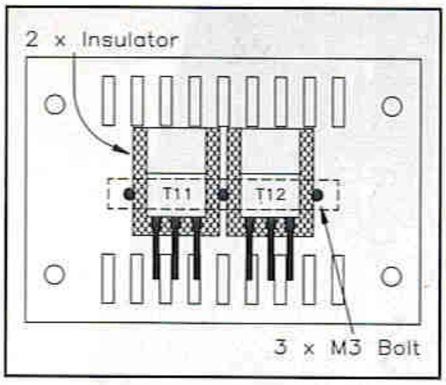


Figure 7a. Insulators and T11 and T12 mounting on end plate.

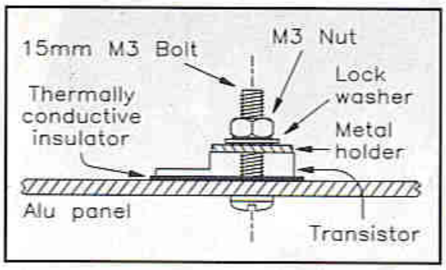


Figure 7b. Fitting the metal bracket.

will be charged through R20. The Zener diode ZD1 is required to stabilise the charge voltage and therefore the discharge/charge time, determined by R13.

A4 is set up as a comparator trigger with its inverting input connected to V_{ref}. Again, if the non-inverting input is higher than the inverting input; then the output will be high and disable IC4 via pin 10 until capacitor C14 is discharged; which will only happen if the supply is disconnected.

Construction

Photo 1 shows the completed PCB, which will help in the identification and placement of components. It is best to fit the wire links first, and these are marked 'J' on the PCB. The two exceptions are 3XJ where three wire links are fitted in parallel and soldered together, and position ZD4 where a link is fitted for the +12V DC version.

Referring to the circuit diagram in Figure 3 next fit the resistors, starting with the ¼W, ½W, 1W types. When mounting the two 3W resistors, stagger them above the board at 10mm and 15mm from the PCB to the top of each component.

Next fit the diodes making sure that their orientation is correct. When mounting diodes D18 to D21 there should be 20mm from the PCB to the top of each component. Do not fit LEDs LD1 and LD2 at this stage.

Locate and fit Zener ZD1, making sure that it is correctly orientated on the board. When fitting ZD2 and ZD3, these should be mounted 10mm from the PCB to the top of each component. A link is fitted in place of ZD4 in the +12V version.

Identify and fit the inductor, as it looks similar to a resistor but has a pale blue or green case.

Next fit the one 14-pin and four 16-pin

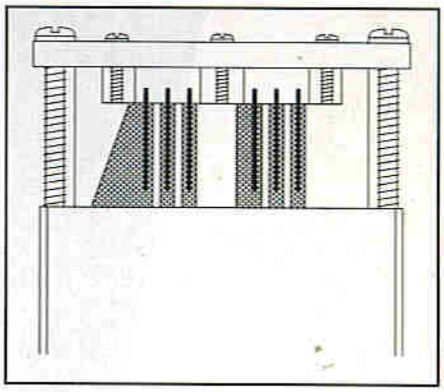


Figure 7c. Soldering T11 and T12 devices to the PCB.

DIL IC sockets, making sure that the notches on the sockets match those on the PCB.

When fitting the capacitors, observe the correct polarity on the electrolytics. The positive lead is normally longer, and the negative is shown by a series of arrows or – symbols on the casing.

Solder the four PCB blade terminals which are marked 'GND' '+V' and the two 'AC' onto the PCB. Next identify and mount VR1 the 7812 regulator, making sure that the metal heatsink matches the legend on the PCB. Matching the outlines of T1 and T2 solder these onto the PCB, and then fit the crystal, PCB pins and switch SW1.

Refer to Figure 4 for fitting T3 & T4, note that they are mounted flat on the PCB, and held in position by a 12mm M3 bolt, shakeproof washer and nut. Figure 4 shows also the vertical fitting of T5, T6 & TS (thermal switch). Note that T5 has its own heatsink and that T6 & TS

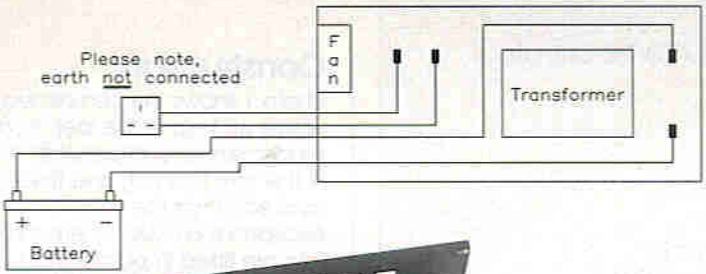


Figure 8. Simple wiring diagram.

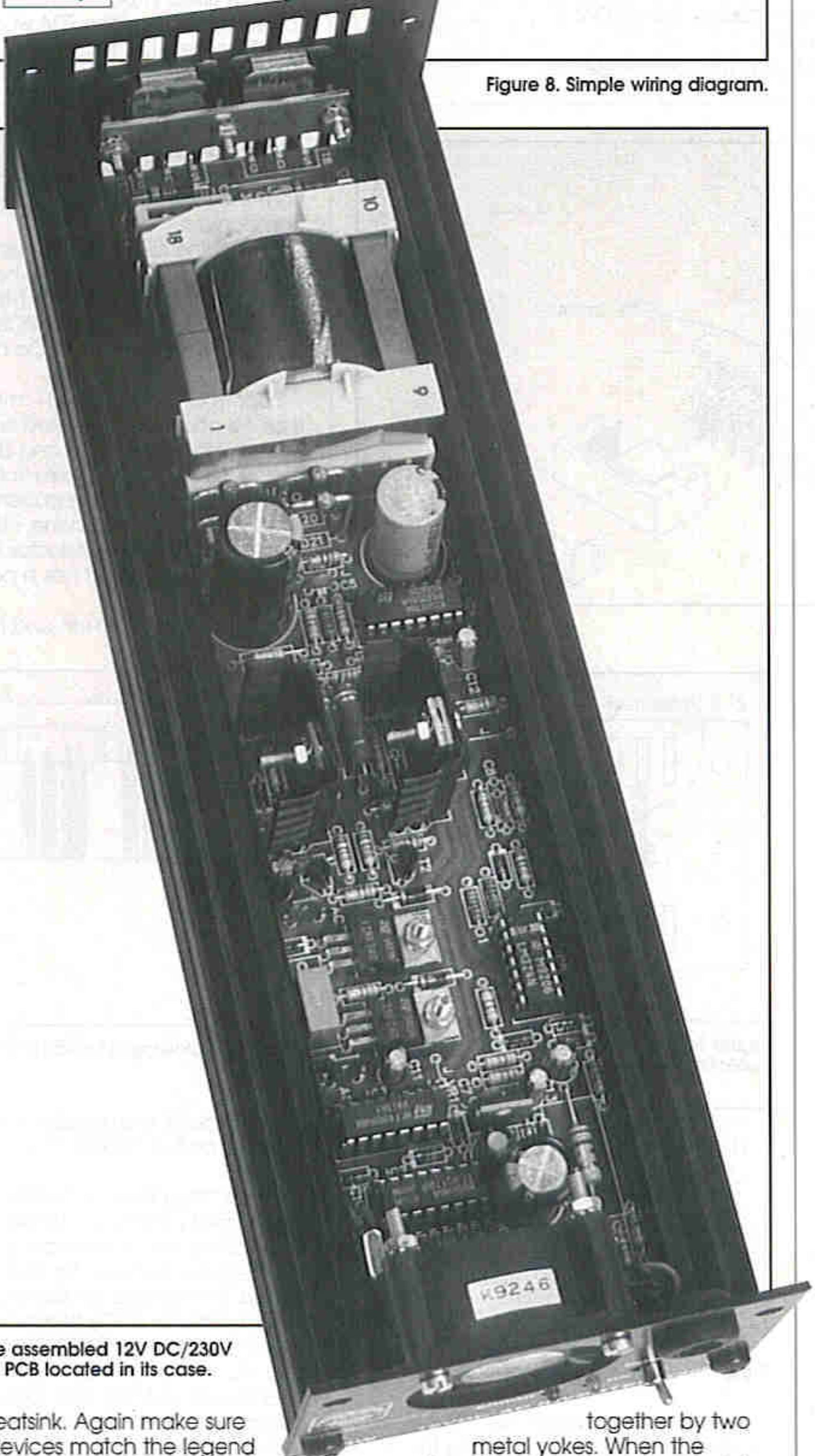


Photo 2. The assembled 12V DC/230V AC Inverter PCB located in its case.

share a heatsink. Again make sure that the devices match the legend on the PCB.

Solder the fuse holder in position and push the fuse F1 into its holder.

Next fit the ICs into the DIL sockets, correctly orientating them so that the notch on the ICs matches those of the sockets.

Assemble the transformer as shown in Figure 5. It is formed by fixing together sections of coil formers, cores, and held together by two metal yokes. When the assembly of the transformer is complete, mount it onto the PCB with the markings on it matching those on the board.

Next fit the red and green LEDs LD1 and LD2. These are fitted and soldered in under the PCB, see Figure 6 for mounting details.

Referring to the drawings in Figure 7a place the two thermally conductive insulators onto the end plate, and using a small amount of thermally conductive paste applied on top, fit T7 and T8. A metal retaining plate can then be bolted to the cover holding T7 and T8 in position by three 15mm M3 bolts, nuts and shakeproof washers, the order of which is shown in Figure 7b.

Bend the legs of T7 & T8 and solder to the PCB, ensuring that the legs are soldered in the correct place to enable the end plate to fit flat against the case. See Figure 7 which shows mounting details.

Assembly

For assistance in assembly Photo 2 shows the completed 12V DC/230V AC Inverter mounted into its metal case. Screw the end plate (with the large hole) to the larger of the two halves of the case. Attach the fan to the end panel using the two M3 30mm bolts, nuts and shakeproof washers provided. Half slide the PCB into the slot, solder the red (+) and black (−) wires from the fan (blower) to the PCB; the position is marked by (−B+).

Fit the grommet in place above the Power 'On' switch.

Solder the blade terminal connectors onto the heavy duty red and black wires. Connect the black wire to 'GND' blade terminal and the red to +V blade terminal. Feed the free end of the wires through the grommet, and solder the large crocodile clips to the wires. Solder the blade terminal connectors onto the twin mains DS live and neutral wires, and connect to the blade terminals marked 'AC'. Feed the free end of the cable through the grommet, and connect a 13A trailing socket to the mains cable. Now slide the PCB fully home, making sure that the wires passing through the grommet are not too slack and screw the end plate in position, see Figure 7c. Photo 3 shows the completed unit with the wires in position. Make sure that the leads are not catching and fit the top half of the case and screw in place. Figure 8 shows the battery and trailing lead connections. This completes the assembly.

Some devices may offer a capacitive load (computers and some battery chargers), as a result the inverter's heat protection circuit may operate after a short while. It will be necessary to wait a few seconds before resetting the inverter, as it is important to leave the inverter switched on so that the fan can operate.

After the inverter has gone into overload or short circuit protection, it must be reset by switching the unit off, waiting for 10 seconds and then switching the unit back on.

During continuous use of the inverter, it is advisable to leave the vehicle's engine running, to prevent the battery being discharged.

Important Safety Warning

The 230V AC output from this inverter, and the high voltages present inside the inverter, are potentially lethal and must

Photo 3. The completed 12V DC/230V AC Inverter, with wires attached.

be treated with the same respect as mains voltage. Every possible precaution must be taken to prevent the possibility of electric shock. Since this unit does not provide any connection to the earth pin of the trailing socket, it must be used only with Class II double insulated equipment displaying the □ double square symbol. Under no circumstances should Class I equipment, requiring an earth connection, be connected to this unit. Under no circumstances should any connection be made to the earth terminal of the trailing socket. Failure to observe these precautions is likely to expose the user to electric shock and possible fatal electrocution. If in any doubt as to the correct way to build or use this unit, seek advice from a suitably qualified engineer.

12V DC/230V AC INVERTER PARTS LIST

RESISTORS (All 0·25W unless specified)

R1	10M	1
R2-12,39	10k	11
R13,14	1M	2
R15	4M7	1
R16,17	47k	2
R18,19	100Ω	2
R20,21	100k	2
R22	470k	1
R23-25	3k3	3
R26	1k2	1
R27-29	10Ω	3
R30	820Ω	1
R31	27k	1
R32	1k5	1
R33	5k6	1
R34	8k2	1
R35	1k	1
R36	56k	1
R37	16k	1
R38	2k7	1
R40	330k (0·5W)	1
R41,42,45	1Ω(1W)	3
R43,44	1R8Ω(3W)	2

CAPACITORS

C1,C2	22pF	2
C3	1nF	1
C4-7	10nF	4
C8	100nF	1
C19,20	22nF 600V	2
C9-13	2μ2F 50V Min Electrolytic	5
C14	33μF 16V Electrolytic	1
C15	100μF 25V Electrolytic	1
C16	1000μF 35V Electrolytic	1
C17	47μF 350V Electrolytic	1
C18	2200μF 16V Electrolytic	1

SEMICONDUCTORS

T1,T2	MPSA44/BF844	2
T3-6	IRF740	4
T7,8	RFG40N10	2
IC1	4060	1
IC2	4017	1
IC3	4009	1
IC4	SG3525A (SMPS)	1
IC5	LM324	1
D1-14	1N4148	14
D15,16	1N4007	2
D17	6A6	1
D18-21	BYT56K	4
ZD1	3V9 Zener	1
ZD2,3	62V 1·5KE62	2
ZD4	Wire Link (see text)	1
LD1	Red LED 3mm	1
LD2	Green LED 3mm	1
VR1	L7812 Regulator	1

MISCELLANEOUS

	PCB	1
L1	220μH	1
TR1	Transformer TR3507	
	Yoke	2
	Core	2
	Coil Former	1
TS	90°C Thermal Switch	1
SW1	SPDT Min Switch	1
X1	2·4576MHz Crystal	1
F1	30A Fuse	1
	16-pin IC Sockets	5
	Heatsinks	2
	Thermally conductive insulators	2
	Fan +12V DC	1
	Spade Posts	4
	Spade Connectors	4
	Case	1
	M3 x 12mm Bolts	2
	M3 x 15mm Bolts	3
	M3 x 30mm Bolts	2
	M3 Nuts	9
	M3 Shakeproof Washers	9
	Metal Retainer Plate	1

OPTIONAL (Not in kit)

Trailing Mains Socket	1	(HL73Q)
2-core Mains Cable	As Req.	(XR47B)
Silicone Grease Tube	1	(HQ00A)

The Maplin 'Get-You-Working' Service is available for this project, see Constructors' Guide or current Maplin Catalogue for details.

The above items (excluding Optional) are available in kit form only.

Order As VF35Q (12V DC/230V AC Inverter)

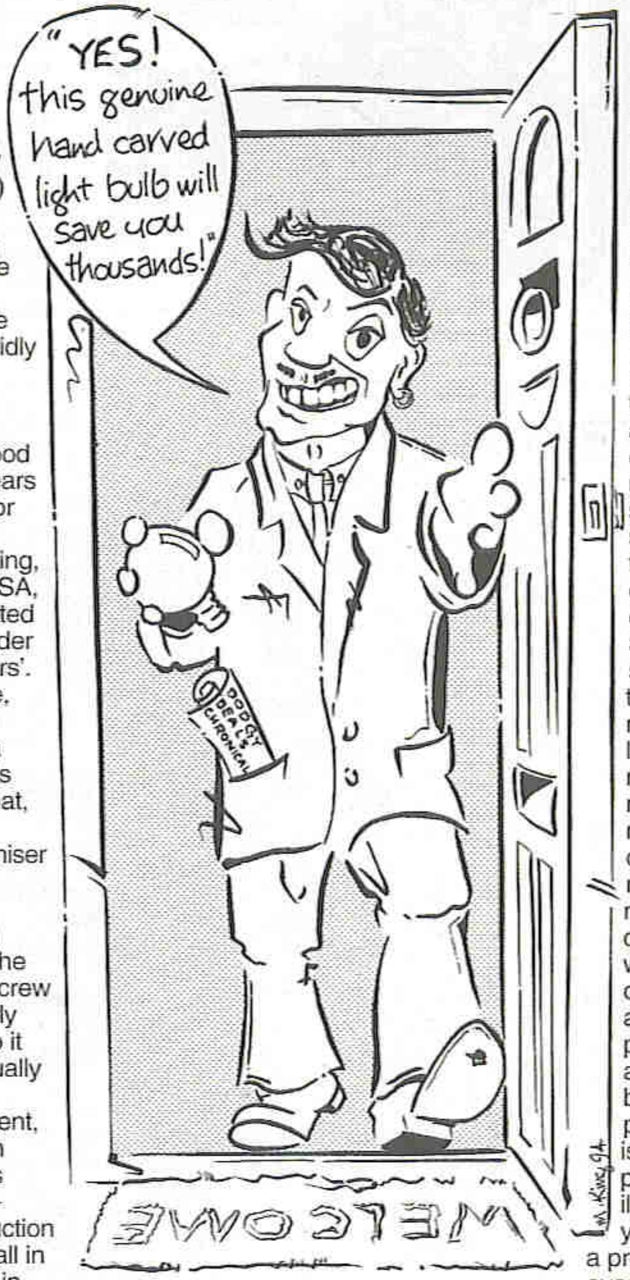
Price £119.95 B4

Please Note: Some parts, which are specific to this project (e.g., PCB), are not available separately.

Stray Signals

by Point Contact

As I write, Christmas approaches, although I realise that by the time you read this, Easter will have passed and midsummer on its way. Certainly the dark evenings (and mornings) will be a thing of the past for another year. At present though, lights are needed for much of the time, even throughout the day, when the heavy black clouds are lower. With the recession still vividly in our memories, and with it still affecting many both here and abroad, any scheme for saving money must *prima facie* be a good idea. One such idea which appears from time to time, is a scheme for extending the life of tungsten filament lamps for domestic lighting, by under-running them. In the USA, where such lamps are usually fitted in Edison screw holders, mail order firms advertise such 'economisers'. "They not only increase lamp life, they actually reduce the current drawn at the same time"; what a wonderful idea! Unfortunately it is all a big con. Yes, they do just that, but at the expense of a greatly reduced light output. The economiser consists of a thin silicon rectifier button mounted at the centre of a disc of insulating material; you simply unscrew the bulb, place the disc on the centre contact and screw it back in again. Now, current only flows on alternate half-cycles, so it is substantially reduced: not actually halved, because at the reduced running temperature of the filament, its resistance is much lower than at full brightness. The brightness however, is drastically affected – roughly speaking every 1% reduction in lamp current results in a 4% fall in light output and a 12% increase in lamp life. If you can accept the greatly reduced light output of a lamp with such an 'economiser', you would be in the first place, far better off fitting a lower wattage bulb. After all, the cost of a bulb is less than a tenth of the cost of the electricity it uses in its life, so where's the saving? The only merit of the scheme is where access for bulb replacement is very difficult, over a high stairwell for example. Even there, the obvious solution is a long-lasting rough-service lamp, as obtainable at any good hardware store. Fancy devices such as mailorder economisers only improve the financial well-being of the vendors.



With the increasing use of surface mount devices (SMD), everything from resistors and capacitors to inductors, transistors, ICs and even transformers, equipment is being miniaturised to an ever greater extent, with of course the elimination of hand soldering of individual components. It should all lead not only to greater productivity in manufacture, but also to greater reliability and hence better value for the end customer. Unfortunately a nasty problem is rearing its head and putting an ugly fly in the ointment. Surface mount multilayer ceramic capacitors are widely used as decoupling components in analogue, digital and RF circuits. The end connections are plated areas, making contact with the edges of metal layers forming the plates of the capacitor. Many experimentally minded readers will know that it is not a good idea to try reusing such capacitors, since the end plating can easily come adrift from the capacitor body during repeated soldering operations. In normal manufacture, in theory, there should be no problem. In fact there is a problem with board flexure. This can be caused by a bed-of-nails test fixture, the straightening of a warp as a board as it is installed in an end-product. Pick-and-place machines loading the second side of double sided boards, and separating individual 'biscuits' from the larger boards, all are often used to take full advantage of automatic assembly machines. Such flexure, causing mechanical stress on the device, can crack the end plating of an SM multilayer ceramic capacitor, leaving it making a purely mechanical contact. The board may then pass test, only to fail months later due to moisture or high currents. On a microprocessor board, the resulting inadequate decoupling could cause a malfunction only when a particular sequence of code was run, the fault being almost impossible to trace and probably wrongly attributed to a bug in the program. Careful board handling in all stages of production, test and installation is the only way to avoid such problems. This is a classic illustration of the adage that you cannot 'inspect' quality into a product; it has to be built in at every stage from square one on.

Last summer, NASA was forced to postpone a planned flight of the manned space shuttle Discovery, due to unusually heavy debris from a passing comet. Officials said it was the first time a US manned mission was delayed by a threat from heavenly bodies. It seems that heavenly bodies can pose a hellish threat.

Yours sincerely,

Point Contact

The opinions expressed by the author are not necessarily those of the publisher or the editor.

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by Graham Dixey
C.Eng., M.I.E.E.

Part 8

POWER ELECTRONICS IN THEORY & PRACTICE

In Parts 6 and 7 of this series, we looked at some of the many uses to which the SCR can be applied. In the final part, we examine the triac.

THE TRIAC

The triac can be thought of as comprising two SCRs back to back, with a common gate that controls conduction in one direction or the other as appropriate. Because it is bidirectional, it is not appropriate to refer to the two main terminals as anode and cathode, as in the case of the SCR, but to call them, somewhat unimaginatively – Main Terminal 1 (MT1) and Main Terminal 2 (MT2). Pin-out diagrams determine which terminal is which, and the definition of forward conduction is that it takes place when MT2 is positive with respect to MT1, assuming favourable gate conditions, of course. Not only can the device conduct on either polarity of the supply voltage, but the gate current, to trigger it into conduction, can be either positive or negative as well. This gives rise to four modes of operation, these being the combinations that arise from the two possible polarities of voltage between the main terminals and the two possible polarities of gate current (and voltage) to turn the device on. These four modes are quite different, a fact which is not immediately evident but arises from the rather complex construction of the device. From these basic facts, it would seem that the triac will be especially useful when the supply is alternating, since power to a load can then be controlled on both the positive and negative half-cycles as required. The SCR, as an individual unit, can only control load power on those half-cycles when the supply makes the device anode positive with respect to its cathode. For full-wave power control we should have to employ two SCRs, one for each half-cycle. This is obviously not as convenient as being able to use a single device. In general, therefore, we shall expect to find the triac almost always employed when the load power is alternating. In this, the final part of this series, we shall look at just a small selection of circuits in which this is the case.

PHASE CONTROL OF TRIACS

Because the basic principle of gate control of a triac is essentially the same as for an SCR, the use of phase control can also be employed. In fact, we should not be surprised that it is used, because, in this method of gate control, the gate control voltage and current are derived from the alternating mains supply, with no other modification than attenuation and shifting its phase with respect to that of the anode supply. A simple RC phase-shift network, with the resistor made variable, could be used. For a greater range of control, two RC phase-shift networks are required and a circuit using this arrangement is shown in Figure 1. These RC networks are cascaded from the mains supply to the gate, the first network having a resistive section comprising a fixed 3·9kΩ resistor and a 220kΩ variable resistor. In this circuit, a diac is used as a trigger device, which is often the case with triac circuits, especially in such applications as: light dimming, universal motor speed control, heating controls, etc. It is perfectly possible to trigger the triac gate directly from the voltage across the capacitor C2, but there is an advantage in doing it indirectly, as it were, through a diac instead. The mechanism of this is as follows:–

The point at which a triac (or an SCR) can be triggered from the non-conducting state into the conducting one occurs at certain combinations of gate current and gate voltage. These combinations are a function of temperature. For example, for a particular device, they might be V_g = 2·9V; I_g = 25mA, at –40°C: V_g = 2V; I_g = 15mA, at +25°C: V_g = 1·7V; I_g = 10mA, at +100°C. It might be thought that the ranges of temperature quoted above are rather excessive. However, it is surprising just what extremes can be met in practice, worldwide. Even interpolating between the above limits over a more restricted range of temperature, say

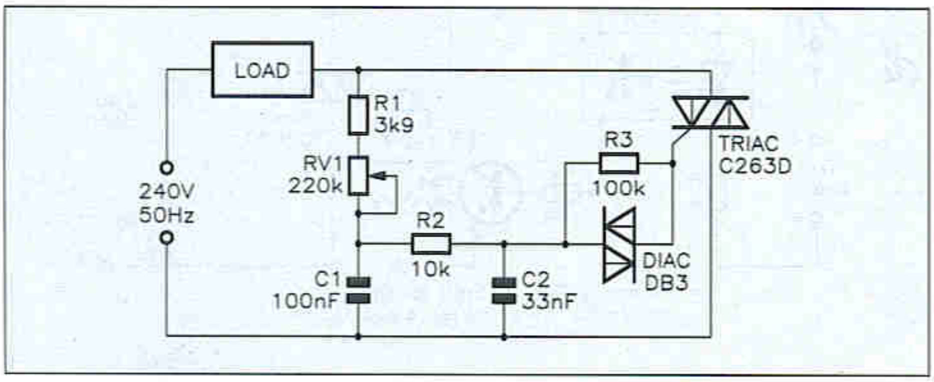

Figure 1. Phase control of the triac with two-stage RC network and diac trigger.

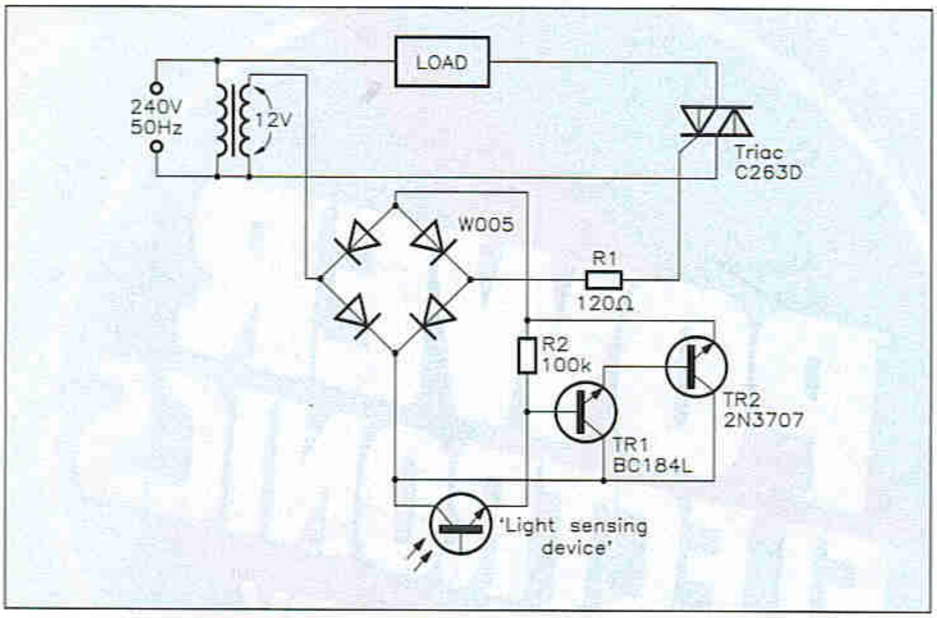

Figure 2. Optical triggering of triac control circuit.

tor. The Darlington pair are non-conducting and there is no path for current into the gate of the triac; the latter is, therefore, non-conducting and the load power is zero. When the light sensing device is illuminated, however, its resistance goes low and a current flows in the 100kΩ resistor, and as such will develop sufficient voltage across it to turn the Darlington pair on. When this happens, the bridge is effectively short-circuited and a current path is created through the Darlington pair and the relevant bridge diodes, resulting in the triac being triggered into conduction and supplying full power to the load.

With the circuit as shown, therefore, a light incident on the sensor triggers the triac on (performing whatever function is required). The operation can be reversed simply by changing the positions of the sensor and 100kΩ resistor. For many applications, the latter arrangement would probably be more logical, since the energising of an alarm or the operation of an automatic door is more likely to be the outcome of interrupting a beam of light rather than energising one.

−20°C to +50°C (a perfectly feasible operational temperature variation) would still show a substantial variation in V_g and I_g. Just what is the significance of all this?

Imagine the alternating waveform rising from 0V at the crossing point; variations are with respect to time, of course, which means that, at some specific instant, the right conditions for triggering will occur. If the values of V_g and I_g that caused triggering were constant, then triggering would always occur at exactly the same point in each half-cycle. However, if the temperature varies, (as it surely will) then the triggering point will shift along the time axis, towards the right as the temperature falls, and towards the left as the temperature rises. The triggering point is, thus, unpredictable. Often this situation cannot be tolerated. The answer is to apply *suddenly* (the key word) a voltage/current pulse that is considerably larger than is actually required to trigger the triac and to ensure that this always occurs *at the same instant in time*. As it happens, the breakdown voltage of a diac is very predictable. This means that it will always break down at exactly the same instant of time (from the instant when the supply voltage applied to it rises from zero towards the peak value, whether positive or negative). When it does break down it will partially discharge the associated capacitor (C2 in Figure 1), sending a large pulse of current into the gate of the triac, immediately turning the latter on.

TRIGGERING A TRIAC OPTICALLY

There are cases in which it is useful to be able to trigger a triac from either the application or the breaking of a light source. Such examples might include burglar alarms and automatic doors, to give just two instances. Figure 2 shows a possible circuit.

The supply is the normal 240V 50Hz mains, which is applied to the load and triac in series, as well as to the primary winding of a transformer, the secondary winding of which supplies 12V rms approximately to a bridge rectifier. A circuit for alternating current is established through the bridge rectifier, the 120Ω resistor and the gate-MT1 path back to the transformer secondary. Under normal conditions, the triac will fire during every half-cycle and power will be supplied to the load. So far, so good. Now consider the rest of the circuit.

What we have here is a Darlington pair, strapped directly across the opposite arms of the bridge. The base circuit of the input transistor, a BC184L, consists of two resistive elements, one of which is a fixed 100kΩ resistor and the other a Light Sensing Device. In the original circuit, this device was specified as an LS600, which I suspect is a Texas Instruments device, probably a photo-transistor. What the device does though, is that it then switches from high to low resistance between the dark and illuminated conditions. This being the case, a Light Dependent Resistor (LDR), such as an ORP12 or ORP60, could be used instead. When the light sensing device is 'in the dark', its resistance is high and no significant current flows in the 100kΩ resis-

ISOLATED SWITCHING OF TRIACS

It is sometimes a requirement that there is good electrical isolation between the input circuit that, in response to some stimulus generates a triggering signal, and the main power circuit involving the triac and associated load. Such requirements are dictated by a particular need for safety. Figure 3 shows the use of a pulse transformer to couple the trigger pulse to the triac gate; such a transformer is able to withstand voltages up to about 1·5kV between primary and secondary windings. This circuit also shows the use of digital logic to generate the trigger pulse. With such circuits, the output pulse is a response to a required logical input combination. In the example shown, only the final stages of the logic circuit only are shown. These comprise a 2-input Schmitt trigger NAND gate (running as a gated astable multivibrator at a frequency of about 12 to 15kHz) and a special interface IC, which is a Texas Instruments type SN75451. The latter incorporates a

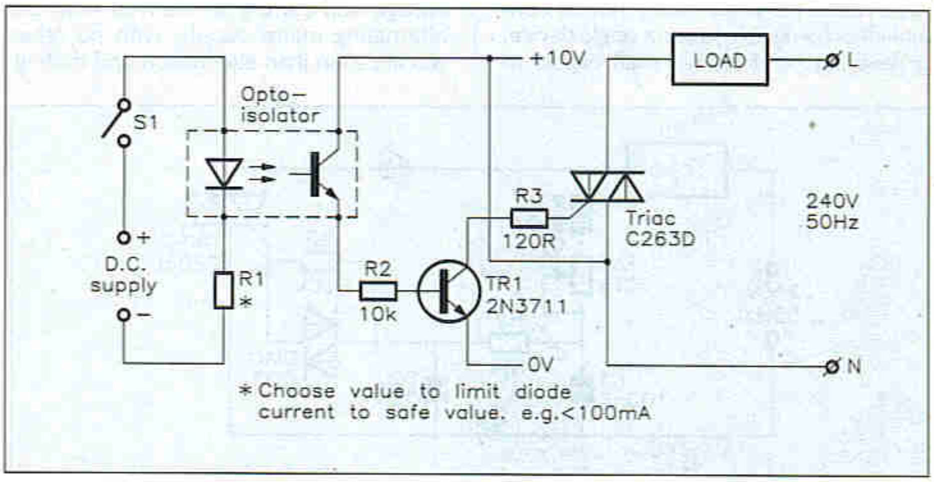

Figure 3. Isolating trigger and control circuits using an optoisolator.

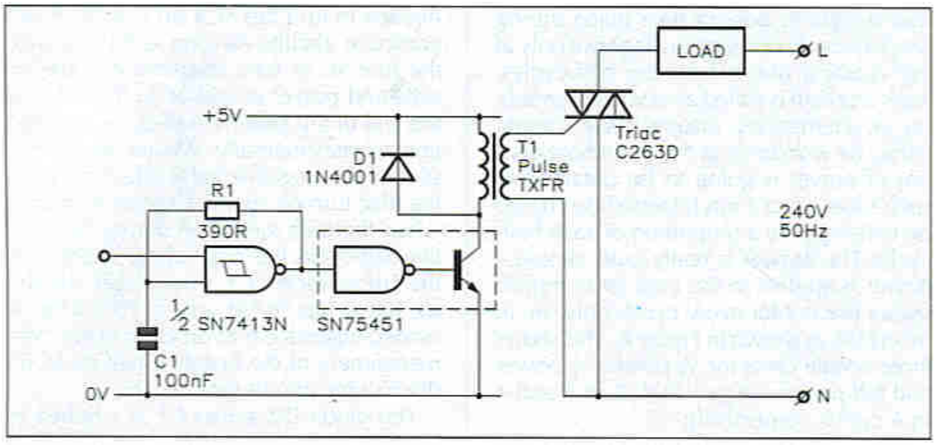

Figure 4. Isolating trigger and control circuits using a pulse transformer.

driver transistor for the pulse transformer. The circuit works as follows:–

The multivibrator is formed by connecting a 100nF capacitor from one input of the NAND gate to ground and bridging this input to the output with a 390Ω resistor. Initially the capacitor is uncharged and the Schmitt output is a 'logic 1' (a logic 0 at either input of a NAND gate always produces a logic 1 output). When the capacitor charges towards the output potential via the resistor, its voltage will eventually reach the upper threshold voltage which causes the Schmitt circuit to change state; the output falls immediately to logic 0. The capacitor now discharges until the lower threshold voltage is reached and the circuit changes state once more. In this way the output of the Schmitt circuit oscillates between the two logic levels. A train of pulses is coupled to the interface device, thence to the gate of the triac via the pulse transformer. These pulses have a current capacity of up to 300mA each. Because of the high-frequency of these pulses compared with the mains frequency of 50Hz, the triac will be fired as soon as the supply voltage reaches the requisite value. Even in the case of inductive loads, where the firing may be delayed, so as not to fire on the first pulse, firing will be almost immediate since the trigger pulses are closely spaced.

No mention has been made yet of the other Schmitt input. This is used to inhibit the multivibrator, so that the train of trigger pulses can be turned on or off in response to this level. This input point is actually the output point of a previous combinational logic circuit. The latter will respond to various inputs and generate the appropriate logic level. In this specific case, the level required to allow the multivibrator to run is a logic 1; the level required to inhibit the oscillator will be a logic 0 (the Schmitt output then sticking at logic 1).

Another method of providing the required isolation is to use an optoisolator, also called an optically-coupled isolator (OCI), as in Figure 4.

This circuit serves to illustrate a basic principle by showing the switching of current through the input of the OCI using a DC supply and single-pole switch. A more sophisticated arrangement than this might well be required in practical cases. However, what is really relevant here, is what is happening at the output side of the OCI.

Smaller triacs require around 5mA of gate current for switching, a value which should be available directly from the output of the OCI. This would make for a very simple circuit. However, if higher gate currents are required, as will often be the case, some current amplification will be needed. Provision for this is included in Figure 4. The 2N3711 transistor acts as an interface between the OCI and the triac gate. This circuit also provides about 1·5kV isolation between trigger and power circuits.

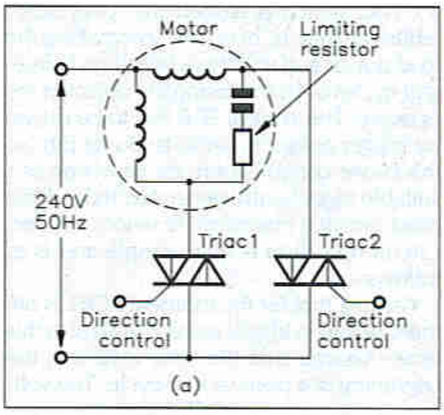

Figure 5(a). Reversing motor control.

REVERSING MOTOR CONTROLS

Often in industrial applications it is necessary to be able to reverse the direction of an electric motor, either manually or by some form of electronic switch, itself actuated by a sensor. Figure 5(a) shows the basis of a circuit which uses two triacs, one for each direction of rotation. The motor type is called a 'split-phase capacitance motor'. As a safety feature, the capacitor has a series limiting resistor which prevents damage to the triacs in the event of both of them turning on at the same time and producing a large loop current due to capacitor discharge. Normally, only one triac at a time is turned on: when one triac is on, the other controls the direction of the motor.

One application for a circuit of this type is in the operation of garage doors, by remote control. Such a system makes use of a transmitter and receiver in addition to the control circuits themselves. The block diagram for such a system is shown in Figure 5(b).

When the garage door is in the closed position, the gate drive to the DOWN triac (TRIAC2) is disabled by a limit switch (lower limit – switch open); at the same time, the output of the AND gate driving the UP triac (TRIAC1) is at logic 0 because the logic level on the flip-flop connection to it is also a logic 0, this arises because the last command given was for 'doors closed'. When the transmitter next sends the 'doors open' signal, the flip-flop changes polarity and sends a logic 1 to the upper AND gate. The inputs to this gate are both now at logic 1 because the 'upper limit' switch is now in the closed state. The UP triac is energised, supplying power to the motor so that it runs to drive the garage doors open. Once they are fully open, the 'upper limit switch' is operated, which opens and inhibits any further operation. The situation is similar to the previous one except that now the system is waiting for the 'doors closed' command, before anything further can happen.

So that operation can be initiated by

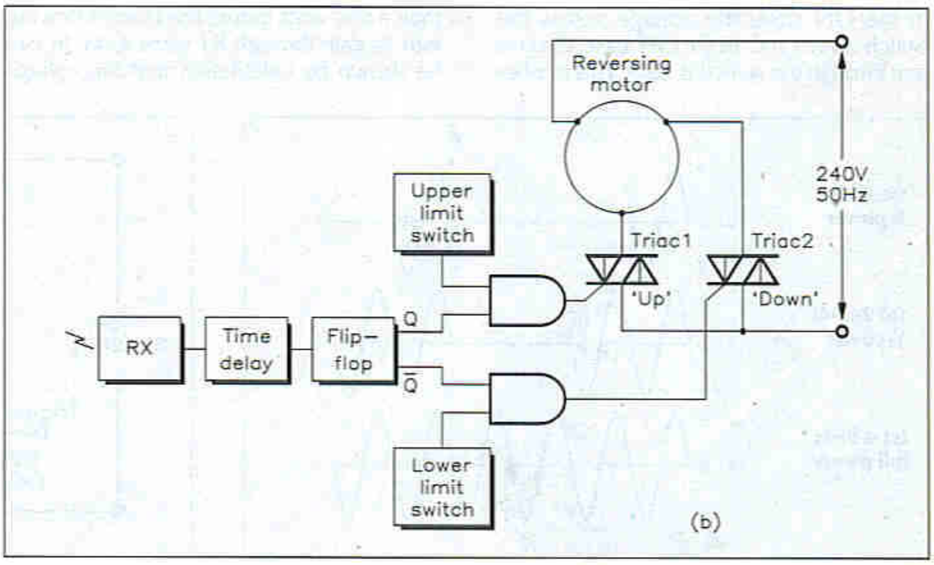

Figure 5(b). Block diagram of remotely controlled garage door system.

nothing more than a momentary keying of the transmitter, a delay circuit is interposed between the receiver and flip-flop. This takes the form of a monostable multivibrator, whose quasi-stable time period is longer than the time required for the doors to open or close. A feature of this system is that an immediate reversal of operation is possible, merely by keying the transmitter button again. This re-triggers the monostable, causes the flip-flop to change state and thus the AND gate outputs also change state, energising the alternate triac. Between the fully open and fully closed positions of the doors, neither limit switch is operated and, hence, both of them output a logic 1.

ZERO VOLTAGE SWITCHING

When the power to a load is interrupted, as in the case of mechanical switching for example, high-frequency components are generated that can create interference for other equipment. This applies also when power is suddenly applied to a load and, in the case of an inductive load (and many industrial loads are inductive to a greater or lesser degree) high induced voltage transients can also be produced.

When it comes to thyristor switching, turn off power to the load is less of a problem because of the inherent mechanism in these devices, namely their latching characteristic. What this means is that thyristors commutate naturally on alternating supplies because conduction ceases when the load current has fallen to a very low value, namely less than the holding current I_H of the device. Interrupting such a small current minimises the electromagnetic radiation. This is not so, however, regarding switching the power *on* to a load. Depending whereabouts switching occurs in the half-cycle of the supply, the current switched may be quite small (near the beginning of the half-cycle) or almost the maximum (where switching is delayed by angles approaching 90°). To produce switching that is totally free of interference requires that switching takes place such as in the ON case, the voltage across the switch is zero and, in the OFF case, the current through the switch is zero. This implies that switching doesn't take place during any half-cycle of supply voltage but only at the crossing points between half-cycles. Such a system is called *zero voltage switching* or, alternatively, *integral cycle control*. It may be wondered at this point how control of power is going to be obtained in such cases since it has hitherto been based on utilising only a proportion of each half-cycle. The answer is really quite simple – power is applied to the load for complete cycles but not for every cycle, only 'm' in 'n' cycles, as shown in Figure 6. This shows three simple cases for 1/4 power, 1/2 power and full power, using 1 in 4, 2 in 4 and 4 in 4 cycles, respectively.

Zero voltage switching circuits are possible in either discrete or integrated form; naturally the latter are rather more convenient. However, we shall first look at a discrete circuit, just to see how it performs its task. One such circuit is shown in Figure 7.

A DISCRETE COMPONENT ZERO VOLTAGE TRIAC SWITCHING CIRCUIT

It will be noticed that altogether this circuit actually has three thyristors: two SCRs and one triac. SCR1 is a C103 type which might be referred to as the 'control SCR'. SCR2 is a C106, which is termed the 'pilot SCR', while the triac is, of course, controlling the load power and will be switched on in integral cycles only, that being the object of the exercise. The control SCR has to be driven by trigger pulses in order to do its job, so this is one complication, the provision of a suitable trigger pulse generator. Indeed this pulse circuit is pivotal to the whole scheme. Circuit operation is quite simple and is as follows:–

Assume that for the moment SCR1 is off, there being no trigger pulse input just at this time. Assume that the time instant is the beginning of a positive half-cycle. The voltage at the anode of SCR2 and the upper end of resistor R1 is rising in a positive direction. It doesn't have to rise by more than a few volts before the current flowing into its gate through R1 turns it on. (It can be shown by calculation that the voltage needed to turn this SCR on is 4·4V in this particular circuit.) As soon as this happens the triac is, in turn, triggered into the on state and power is applied to the load. At the end of this positive half-cycle, the triac commutates naturally. We are now at the start of the negative half-cycle; how does the triac turn on again? The answer is that, when the triac turned on during the positive half-cycle, the load voltage charged up the 1µF capacitor C1, through D4 and R3, so that it has stored energy. The latter is used to trigger the triac on again at the commencement of the negative half-cycle, by discharging into its gate via D3.

The diode D2 across C1 is required to prevent the capacitor from acquiring a charge during the negative half-cycles when the triac is on. Should it do so, it would cause inadvertent switching on of SCR2 during those times when SCR1 was on.

That brings us to the role of SCR1, which can probably now be guessed at. Its function is simply to disable the pilot SCR, SCR2, thus preventing the triac from being triggered. To carry out this disabling function, it has itself to be triggered into the on state. This is where the external trigger pulse generator comes in. Its function is to supply pulses precisely timed to coincide with the crossing points of the mains supply voltage, but occurring only at those times when the triac is required NOT to turn on. This is not too difficult to do. The design of a crossing-point detector is quite straightforward and all that is needed then is to control the frequency of the pulses as an inverse function of the load power to be controlled.

AN INTEGRATED CIRCUIT ZERO VOLTAGE SWITCH

An example of an IC that performs the functions just discussed, which also incorporates the crossing-point detector and the trigger pulse generator (all this in an 8-pin DIL package!) is the GEC-Plessey SL441CDP Zero Voltage Switch. This is specifically designed for 'burst firing' of triacs (an alternative expression for what we have just been discussing) and is suitable for

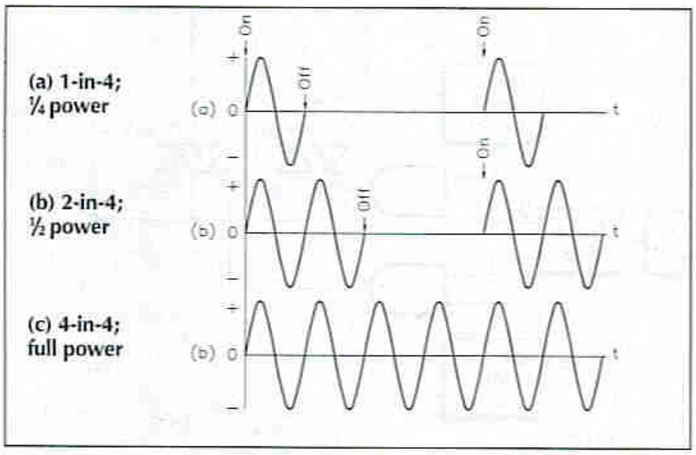

Figure 6. Integral cycle control.

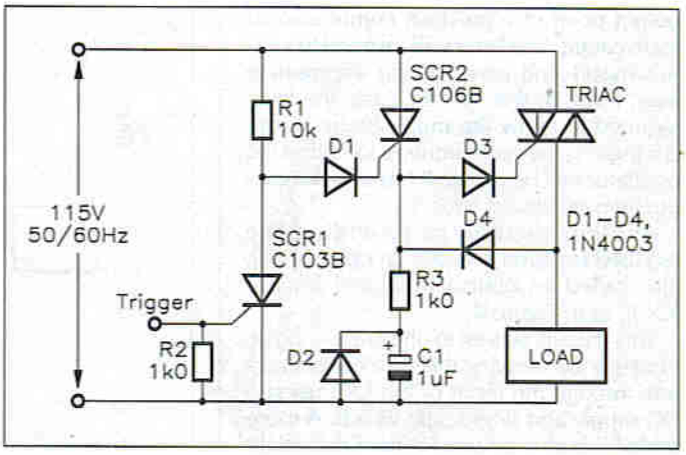

Figure 7. Discrete components zero voltage switching circuit.

controlling space heating appliances such as panel heaters and fan heaters. Details of this device, including its pin-out diagram, appear on page 572 of the 1994 Maplin Catalogue.

A SPACE TEMPERATURE CONTROL SYSTEM

Having just mentioned the role of one IC in the area of space heating Figure 8 illustrates the use of another IC, the PA424 (GEL300F1), in the same type of application. This system also uses zero voltage switching and provides proportional control of temperature as follows:–

First consider proportional control. This is essentially a form of on/off control but with a built-in anticipatory function. This can be implemented by 'modulating' the sensor, either electrically or thermally, with an independent signal. One method of doing this is by placing an auxiliary heater close to the sensor so that the latter heats up more quickly. Care is required in such designs, the objective being to design a system that avoids 'hunting and overshoots' that often occur in heating systems controlled by a temperature sensor. A good example of this is the thermostat commonly used in domestic central heating systems which always seem to be set either just a bit too low or a bit too high for one's own personal comfort!

A somewhat different approach is used in the case of the system of Figure 8. Here a 'modulation generator' is built from a 2N6028 PUT, this producing a sawtooth waveform with a 30 second time period. This waveform is coupled by a 2N3391 buffer transistor into the sensor and reference circuit where it gives a modulation amplitude equivalent to a temperature change of 1°C at the sensor. With the circuit as shown, it is possible to hold room temperature to within better than ±0·3°C.

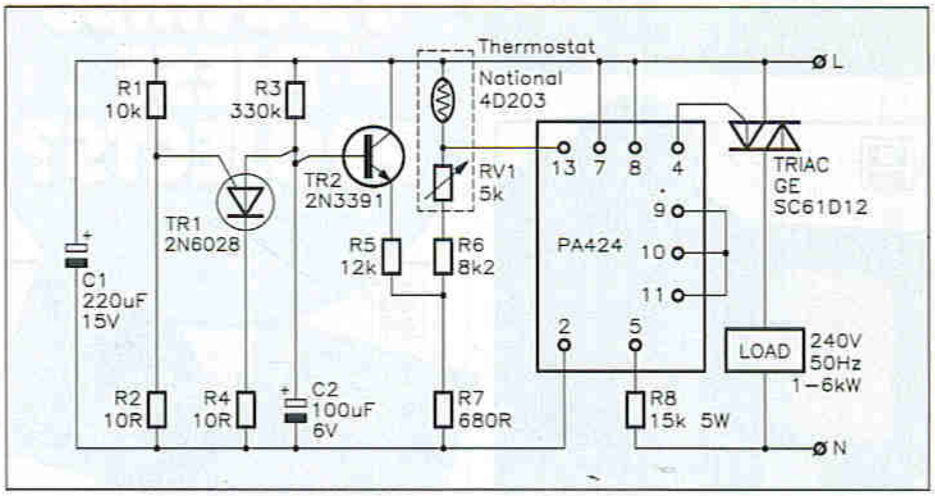

Figure 8. Complete design for a space heating system, using integral cycle control.

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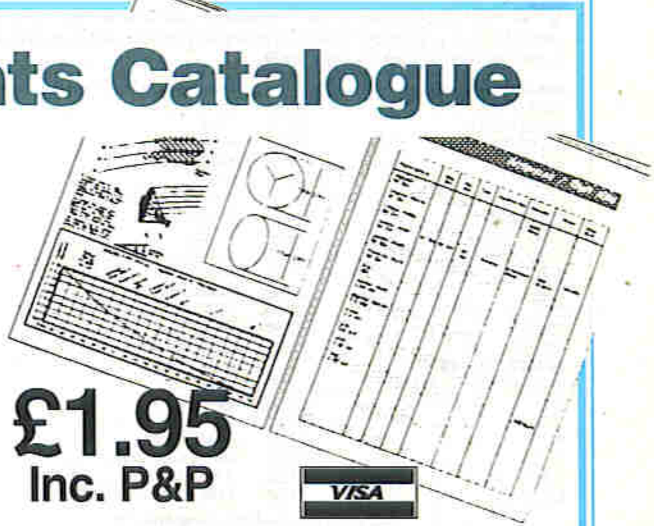

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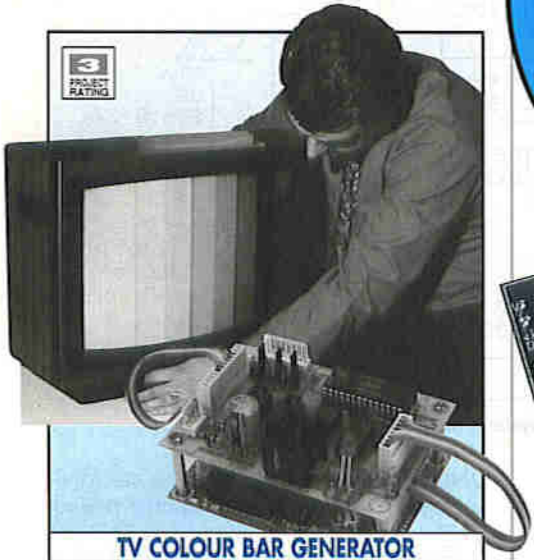

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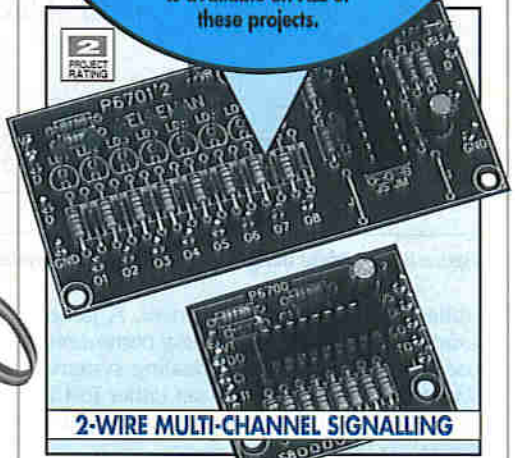

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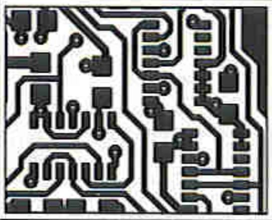

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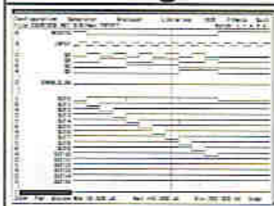

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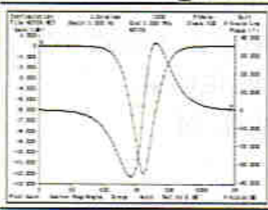

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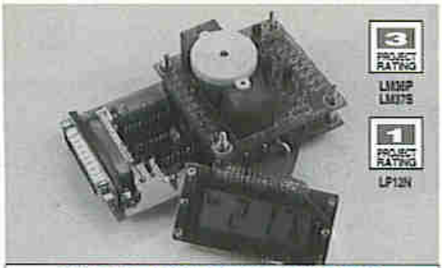

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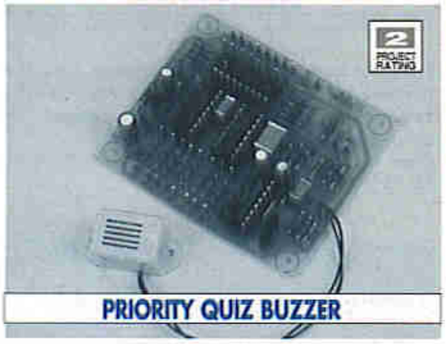

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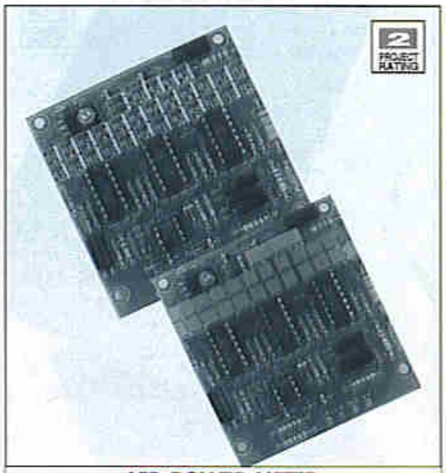

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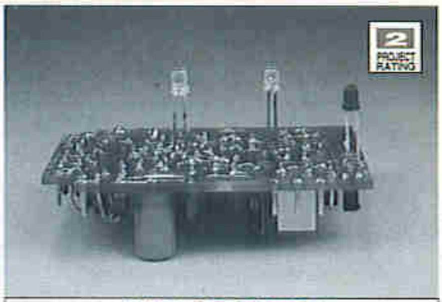

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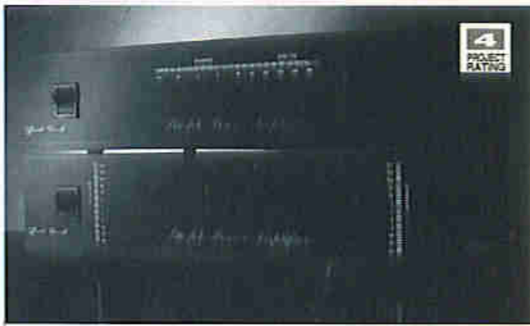

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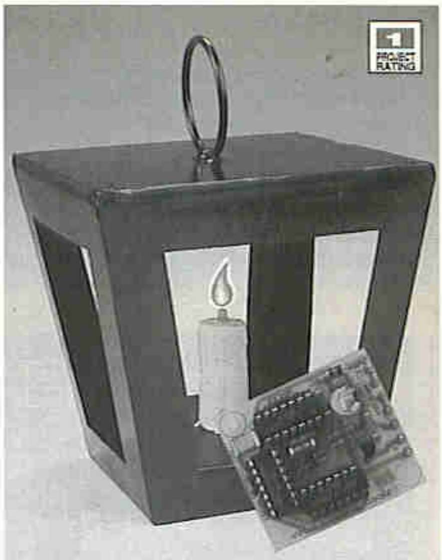

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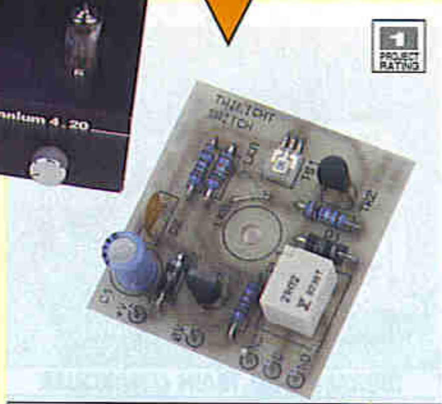
SAVE £20! Complete Millennium Stereo Amplifier Kit (1 x PSU & 2 x Amplifier kits)
Order as: LT72P, Price **£179.85** H18.

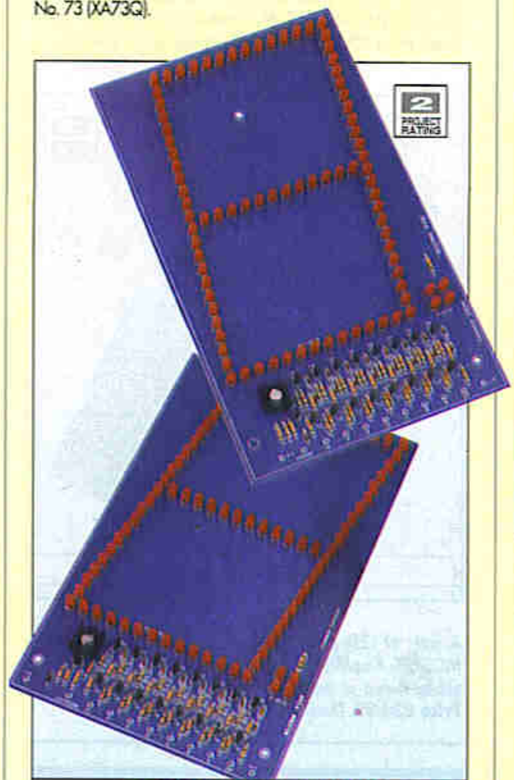
MILLENNIUM VALVE AMPLIFIER PSU

A Power Supply kit for the Millennium 20W Valve Power Amplifier. The supply is capable of powering up to two amplifier modules for a stereo system, or alternatively you could use two PSU kits and two amplifier modules to produce a pair of 'monobloc' amplifiers.
Order as: LT44X, **Price £49.95** C6. Details in *Electronics* No. 73 (XA73Q).



TWILIGHT SWITCH

Using the ULN3390T opto-electronic switch, this versatile project senses the ambient light level and operates the built-in relay at dawn and dusk. Typical applications are automatic control of lighting, night-time security or anywhere that daylight related switching is required.
Order as: LT47B, **Price £5.95**. Details in *Electronics* No. 73 (XA73Q).

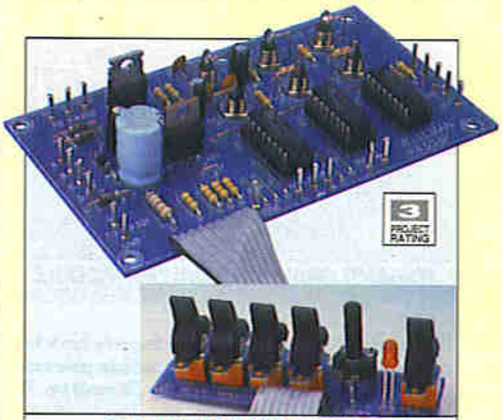


EXTRA LARGE LED DISPLAY

A choice of two 20cm (7 ½in.) 7-segment LED displays, catering for open-collector and open-anode circuits. Ideal for educational equipment, public displays, exhibitions, demonstrations, clocks etc. Connects to existing 7-segment display drivers. Operating voltage: 22 to 26V DC, maximum supply current: 400mA.
Order as: VF01B, Common Cathode Version, **Price £32.95,** or: VE63T, Common Anode Version, **Price £32.95**. Details in *Electronics* No. 74 (XA74R).

MODULAR GRAPHIC EQUALISER FRONT PANEL

A pre-drilled front panel and pre-printed foil to give a professional look to your completed equaliser project. The panel is suitable for a standard 19in. housing having a height of 2 units (2U).
Order as: VE41U, **Price £32.95** A1. Details in *Electronics* No. 74 (XA74R).



GRAPHIC EQUALISER PSU & SWITCHING UNIT

Part of the Modular Graphic Equaliser System. This project provides a regulated power supply for various of the other units in the system, a front panel mounted line input sensitivity control and also provides all of the necessary switching functions.
Order as: VE45Y, **Price £32.95**. Details in *Electronics* No. 73 (XA73Q).

AUTOMATIC REAR WIPER CONTROL UNIT

At last! Comprehensive control for rear window wipers, tied into the operation of the front windscreen wipers and gearbox. Facilities include: Single shot (when front wipers turned on), Intermittent operation (when front wipers on), and Auto wipe (Reverse gear selected and front wipers on).
Order as: LT46A, **Price £9.95.** Details in *Electronics* No. 74 (XA74R).

DID YOU MISS THESE PROJECTS?

The Maplin 'Get-You-Working' Service is available on ALL of these projects.

These descriptions are necessarily short. Ensure that you know exactly what the kit is and what it comprises before ordering, by checking the issue of *Electronics* referred to in the list.

The referenced back-numbers of *Electronics* can be obtained, subject to availability, at £1.95 per copy.

Carriage Codes – Add; A: £1.45, B: £2.10, C: £2.65, D: £3.15, E: £3.70, F: £4.25, G: £5.10, H: £5.70.

To order Project Kits or Back-numbers of *Electronics*, 'phone Credit Card Sales on (0702) 554161. Alternatively, send off the Order Form in this issue, or visit your local Maplin Store.

See advertisement elsewhere in this issue for locations of Maplin Stores.

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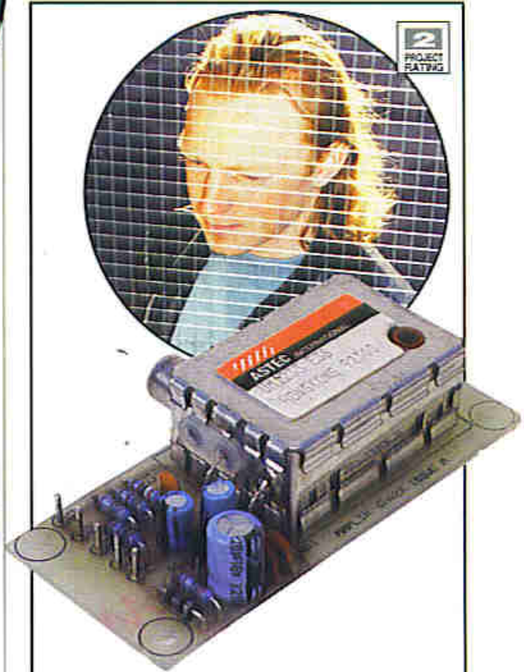
All items subject to availability. Prices include VAT.

CAR INTERMITTENT WIPER CONTROLLER

An essential device for those of us with older cars and classics, that weren't built with anything more sophisticated than an on/off switch on the wipers! This simple to build project produces three delay periods, and has an LED indicator which lights during the delay period, reminding you that the unit is operating.
Order as: VE03D, **£12.95**. Details in *Electronics* No. 75 (XA75S).

AIRCRAFT BAND RADIO RECEIVER

Listen in on pilot and control tower communications with this super AM airband receiver. The kit is simple to build and requires little alignment. Frequency range is 118 to 135MHz and the receiver operating voltage is 9V. (Optional case not included.)
Order as: CP17T, **£29.95**. Details in *Electronics* No. 75 (XA75S).



CCD CAMERA TV MODULATOR

A low-cost unit which allows the Maplin colour and black & white CCD Camera Modules to be linked to any normal domestic TV with UHF aerial input. Applications include closed-circuit security systems, and interfacing equipment that only has video outputs to a normal TV receiver.
Order as: LT37S, **£9.99**. Details in *Electronics* No. 75 (XA75S).

The assembled receiver in its optional case (not included).

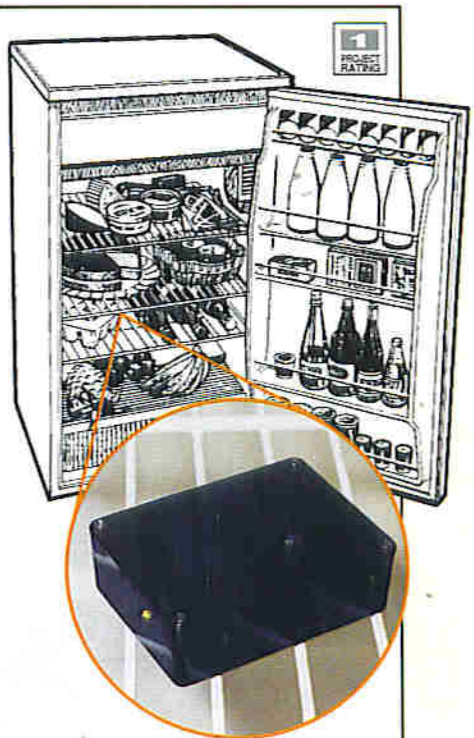
20 METRE ALL MODE RECEIVER

A 'direct conversion' 'DC' type receiver that is both simple-to-build and easy-to-use as there is no 'intermediate frequency' (IF). Frequency range is 13·85 to 14·50MHz and the receiver operates from a standard 9V PP3 battery (not supplied).
Order as: CP13P, **£31.95**. Details in *Electronics* No. 76 (XA76H).

The assembled transmitter in its optional case (not included).

20 METRE CW TRANSMITTER

A crystal controlled CW transmitter operating on the 20m band. The crystal frequency can be shifted by up to 5kHz by the VXO control. The transmitter operates from a +12 to +15V DC supply and has an RF output of 1W. Note: To operate this transmitter legally, either a full Class A Amateur Radio Licence or a restricted Novice Licence is required.
Order as: CP09K, **£31.95**. Details in *Electronics* No. 76 (XA76H).



FRIDGE CHECK

Is your fridge always as cold as it should be? This easy-to-build unit constantly monitors the temperature inside your fridge. If it exceeds a preset limit the alarm sounds, alerting you to the potential dangers of bacterial growth and food poisoning.
Order as: LT53H, **£8.49**. Details in *Electronics* No. 76 (XA76H).

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